

Structured wine with syntropy

The Phi'on research team are always looking for new science to explain the effects that our **Magnetised, Energised and Activated: MEA** water restructuring devices have on wine quality and integrity, along with many other liquids (eg. raw milk, fruit juices, bottled water, etc.).

New Scientist magazine recently published an article that explains the importance of yeast diversity and abundance in the wine fermentation processes. Several wine and biotechnology scientists, mainly in Europe, have produced interesting evidence that the *wine nose* is not about the wine grape per se: it is the **esters** produced by the yeast in the fermentation process. The New Scientist article is attached to this essay.

This knowledge about the effects of esters throws new light onto past observations by the Phi'on team about the effect of restructuring the water in wine to hold a permanent negative charge. Also, Phi'on had observed and patented new knowledge about a unique relationship between microbes and structured water in plant growth (eg. grape vine) and fruit integrity.

This essay explores ways to enjoy wine in a healthier and more satisfying manner. Consequently, our thesis, in this essay, is that the quality and integrity of wine can be significantly improved through restructuring the wine juice (80-85% water) with a MEA water device to hold a **permanent negative (-) charge**. This process can be prior to fermentation by passing the grape juice through a MEA water restructuring device to the fermenters and during the bottling process to achieve **syntropy wine** (ie. *life-affirming wine that that accumulates quality or integrity and never decays*), that is discussed further on page 3.

Background

Many people enjoy wine because the act of pouring wine into a glass is the point of relaxation at the end of a day or at the beginning of an event. The wine elevates the subtle flavours in a meal and brings depth and inhibition to the conversation.

There is recent science that points to the link between **electrical charge (current) in the mouth** and a person's capacity to differentiate tastes (flavours). Consequently, when the water in wine has a high negative charge (say above -250mV) then the different wine flavours will be sensed in a more heightened manner.

We often read in scientific and general articles that wine can be healthy. However, not all wines can be put into this category. Just like: not all foods are healthy, not all wines are healthy. The health or integrity of a wine depends on the type of wine you drink, and more importantly how the grapes are grown and prepared for fermentation and bottling.

Wine integrity

Most vineyards are sprayed with pesticides, herbicides, and fungicides to protect their crops from insects and infection. These chemicals get in the soil, the grapes, and ultimately in the

wine you drink. Grapes (particularly table grapes) are near the top of the *Dirty Dozen* foods sprayed with the most chemicals. You avoid these chemicals in your food by choosing organic produce, and similarly you should choose organic or biodynamic wines.

Grapes have a thin and porous skin, and this means they absorb the chemicals more readily through the skin membrane. Also, wine is the concentrate of many grapes (600-800 grapes per bottle) and consequently the result can be a condensed source of toxic chemical compounds if the grapes are sprayed with chemicals. For example, in a 2018 test for glyphosate (from the weed killer: Roundup) levels in wine grown in California (USA), it was found that 100% of the wine tested had glyphosate.

Wine additives

Wine producers, globally, can use many different types of additives in wine without disclosing any of them on the bottle. The wine could include:

- defoaming agents and artificial colouring
- extra sugar, including high fructose corn syrup, and ammonia
- genetically modified bacteria and yeasts that are either present on the grapes in a vineyard or added to the fermentation
- Fining and clarifying agents like egg-white, casein or polyvinyl-polpyr-rolidone (PVPP), and sulphites, preservatives and a lot more

When we learn about the additives used in winemaking we realise that there is minimal labelling or transparency in consumer awareness or education. Wine bottles may have some ingredients listed on the labels, however many other chemicals are potentially not listed. A non-organic/biodynamic wine could have more than 20-30 additives. So, why do we passionately read the label for all foods we buy and only purchase items with organic, clean ingredients, and yet we do not pay adequate attention to what additives are in wine?

Alcohol and sugar

Wines have varying concentrations of alcohol and sugar. This could vary for alcohol from approximately 12-14% and sugar can be as high as 300 g/L for a sweet wine. Human cells must metabolise these compounds because they are toxic to the cell, and therefore the higher the concentration the greater the time for metabolism. Therefore, it would be an advance in wine production if the wine could be made in a manner that reduced this toxicity risk yet enhanced the flavours and enjoyment.

Advances in wine making

In recent times winemakers have been practicing a fermentation technique known as *indigenous yeast fermentation*, and this is the manner that wine was originally made. It has only been in the past 100 years that *packet* (non-indigenous) yeasts have been added to the fermentation process. So why has this technique become the new era in wine making?

Undoubtedly, there is a trend towards a more natural way of making wine which starts in the vineyard with organic or biodynamic grape growing (ie. the biodynamic wines from Whistling Kite, Loxton SA, www.whistlingkitewines.com.au and the Kalleske vineyard that has been certified since 1998 and is the oldest certified organic and biodynamic vineyard and winery in the Barossa Valley: www.kalleske.com) and extends to minimal handling of the wine. The Whistling Kite Winery uses the Biodynamic Farming Practices and have found the vine structure changes during the growing period. The use of the BD501 formulation produces a strong, thick skinned berry that is naturally resistant to disease and fungal challenges. Of course, there are many other wineries that have adopted similar organic or biodynamic practices in Australia and overseas.

The use of wild yeast is one factor in wine quality and integrity, however there are many other techniques that will help in this process. The use of diverse and abundant wild yeast cultures is a tool to create complexity, however the fermentation of the wine in a structured water form enhances flavour, prevents spoilage and ensures that the wine will never turn to vinegar.

Phi'on research findings

Phi'on's water device manufacturing has reached a mature stage, including the stability of the negative charge in the water and its broad application for domestic, agricultural and industrial uses. Wine is about 80-85% water and therefore this water can be restructured to permanently hold a negative charge. This is innovation for sustainable wine making.

In early 2021, Phi'on received the following email testimonial from Whistling Kite Wines (SA):

AB here from Whistling Kites Winery, just wanted to drop you a quick line with some interesting results. Last vintage, I dipped my toes in the water (wine?) of making it myself and processed approximately 200 litres of wine at a different facility than usual. I wanted a little more control over the process, and made the wine with no additives, no preservatives, just grapes. As you know, our winery has been using the Athena ¾ MEA Device for a couple of years now, but they have never had a control to compare it to. Therefore, that is what I did, and on December 28th, I bottled the first ¾ batch through the Athena, and the remainder without. I have to tell you, I am glad I did the bulk of it through the MEA device, the difference is quite evident. The wine that ran through the unit is where you would expect the wine to be after 18 months. It is a lot more vibrant, and lively (there is even a difference visually!). It is almost as though the MEA device has eliminated bottle shock. Finally, a friend tested a sample of both on his radionics machine to measure the vitality and got a reading of 1300 vs 750! I know this is probably old news to you, but I wanted to share it, I will be bottling all of my wine through the MEA unit in the future:~) AB from Whistling Kites Winery.

It is the dynamics of energy in structured water that determines the degree of order or disorder in crystalline structure of the water. In effect, this process is about turning the water in wine into a crystal liquid structure and this structure opens the pathway for water to receive, store and transmit life affirming energy. This energy is usually described as either entropy (**entropic** structure) or non-entropy (non-entropic or **syntropic** structures). **Entropy** defines something that, left on its own over time, will gradually decline into **disorder**. This is the case when

structured (syntropy) water is taken from a pristine, flowing stream and is stored in a container (eg. a bottle): it converts from a six-sided crystalline structure into a five-sided crystalline form (unstructured or de-structured) within 60 hours. Consequently, the urban water (and most other fluids) that human's drink on Earth (including bottled wine) is unstructured (entropy) water. **Syntropy** (non- or negative entropy) describes something which does not decay or decline, however when left on its own over time will progress or change into a state of higher function or **order**. For example, a solid crystal (including a diamond) will persist without decay.

Phión has invented and produced water devices that will sustain syntropy in water. This innovation has endless capabilities for sustaining cell potential in the modern era. Phión MEA water is: **SYNTROPY WATER**. It is our aim to facilitate **SYNTROPY WINE**. *Syntropy water in wine is the diamond in the wine.*

Wine that has its water in a structured form with a permanent negative charge could be **on tap** in the same manner as beer in a bar. This would be a revolution in wine presentation and enjoyment, particularly if the wine was biodynamic and organic.

The Phión website for these water restructuring devices is www.meawater.com.au. The MEA website provides the evidence of its advanced capacity for water conditioning and restoring the natural, permanent negative charge to water. The **Phión** MEA devices include: a portable **bottle top device** for home or travelling to condition water, wine, spirits, juices and raw milk; an **under-sink/shower device** that can also be used on an outdoor tap and sprinkler, and 5 **in-line devices** (½", ¾", 1", 1 and ¼" and a 2" inner diameter) for house connections and a broad range of agricultural and industrial applications.

See device images on the next page.



Since 2012, all Phión liquid products have been produced with structured water.

The key areas that differentiate the Phión MEA water devices in the structured water market are:

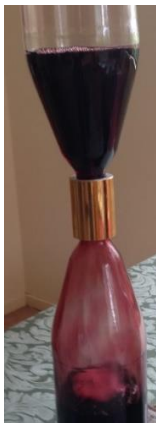
1. The simplicity of design, operation and installation (install and forget). There is **no ongoing maintenance**, except the bottle top device may need a change of the inner washer every 2-3 years depending on usage, however this process is very simple and Phión provides spare washers.

2. The water produced from these devices will **hold a permanent negative charge** (ie. a syntropy force). Phión has checked this capacity in numerous experiments with water and wine. Wine that is restructured will never oxidise (ie. lose oxygen and turn to vinegar). These results clearly demonstrate that the MEA water has a **natural preservative capability**
3. The cost to buy and sustain the device is **highly competitive and value for money** is significant given that it will hold a permanent negative charge and produce significant results in food production and food integrity
4. Phión structured water will **eliminate pathogenic microbes** like E. coli
5. Phión structure water has a **natural bonding with microbes in the processes of digestion, absorption and assimilation of nutrients and elimination** of cellular waste
6. Phión structured water has been proven in independent measurement to **receive (entrain), store and transmit natural wave energies** (eg. Quantum Code Technology: QCT) that will reduce cellular stress levels to a normal range in about 2 minutes.

The Phión bottle-top device can be used to condition wine, as wine is 80-85% water. The other components of wine (excluding preservatives) are described in the image on the next page. A major advantage of using a Phión bottle top device to condition wine is that if the wine is left open to the air (ie. exposed to microbes and oxygen) the wine will **not spoil or oxidise** and turn to vinegar.

There are several notable and positive outcomes from using the Phión bottle **top device to condition wine**. For example, trials with wine have produced significant results that include:

1. Greater balance in wine structure (ie. increased sense of flavours and aroma is intensified)
2. Considerably less tannin and sharpness (acidity) taste that can dominate **flavours**
3. Potentially enhances the beneficial aspects of polyphenols.



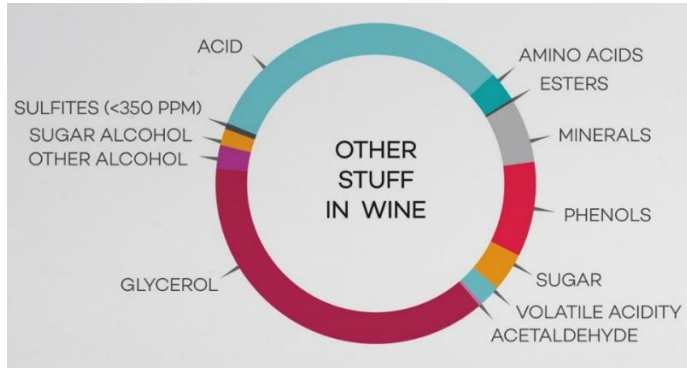
The wine does not oxidise and turn to vinegar when left open to the air for up to 12 months. This is largely due to permanent negative (-) charge held in the wine that eliminates pathogenic microbes that can spoil the wine. Also, the restructuring of the wine to a unique six-sided crystalline structure prevents the loss of oxygen.



Therefore, the Phión in-line, MEA water conditioning devices will become increasingly used to water grapes (and deliver nutrients and biology to the grapevines through fertigation), and restructure the water in wine before fermentation and bottling. The value to the wine producers and makers, is that the wines will not spoil, storage will not adversely affect the wine

and flavours/bouquet will be enhanced. The value for the wine consumer is that the wine alcohol will be more effectively processed by the liver to minimise ketosis and blood acidity.

The image below illustrates the **non-water composition of wine**, including the sulphite preservatives that have a capacity to form free radicals through oxidation.

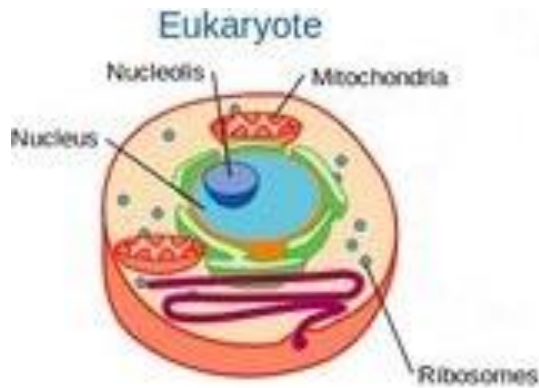


The emergence or presence of acetic acid (vinegar) in wine is an indicator of wine spoilage. If wine is infected with acetobacter bacteria, and other conditions are right, then acetic acid will be produced in the wine, along with lots of other bacteria (eg. the gram-positive, lactic acid bacteria, *Pediococcus*). These bacteria are everywhere: in the air, on fruit, etc. When acetobacter gets into your wine it can slowly turn the alcohol into acetic acid, if left unhindered. Consequently, wine can turn into vinegar when it is exposed to a lot of oxygen and microbes in the air for a long time (within weeks, or months at most).

Also, the microbes that tend to infect wine can quickly turn acetic acid to acetone. Small amounts of acetone are produced in the body by the decarboxylation of ketone bodies. **Ketone bodies** are three water-soluble molecules (acetoacetate, beta-hydroxybutyrate, and their spontaneous breakdown product, acetone) that are produced by the liver from fatty acids. Certain dietary patterns, including prolonged fasting and high saturated fat, and low-carbohydrate vegetable dieting, can produce ketosis, in which acetone is formed in body tissue. Certain health conditions, such as alcoholism and diabetes, can produce ketoacidosis and uncontrollable ketosis that leads to a sharp, and potentially fatal, increase in the acidity of the blood. Since acetone is a byproduct of fermentation, it is a byproduct of distillery.

Thesis arising from Phi'on wine research

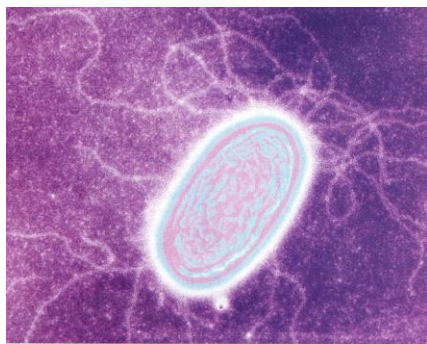
Yeast are single-celled microorganisms that are classified, along with molds and mushrooms, as members of the Kingdom Fungi.



Although yeast are single-celled organisms, they possess a cellular organisation like higher organisms, including humans. Specifically, their genetic content is contained within a nucleus. This classifies them as eukaryotic organisms, unlike their single-celled counterparts, bacteria, that do not have a nucleus and are considered prokaryotes.

All plants, like humans and animals, have their own microbiome of bacteria, fungi and yeast. A single leaf hosts millions of microbes and hundreds of different types. The ones living within the plant's tissues are called endophytes. Plants acquire many of these microbes from the soil, and air, and some are passed from generation to generation through seeds. The endophytes are particularly important for plant vigour and size.

An important characteristic of yeast essential to their role as *model organisms* is the fact they are relatively easy to work with. Yeast replicate quickly and are easy to manipulate genetically. The doubling time for yeast (the time required for a cell to duplicate and divide itself) is about 90 minutes. The beneficial microbes operate as collaborative or supportive communities to assist with photosynthesis, growth, and survival during drought and other stressors, such as disease.



Bacterial 'wires' an electronic dream

The *electronic wiring* of microbes can access and utilise energy from light photons and the negative charge in structured water. This environment then creates the *syntropy energy* or force that counters the *entropy energy* in cells (ie. counters decay such as fungal/mould infestation and improves aging effects). The interaction of water's negative charge and microbe wiring is also a factor in discerning taste (wine flavours) in the mouth.

Image from New Scientist, 13 August 2011

Microbes have a unique association with the *subtle energies* of their environment to sustain their life. Early single celled microbes (like the *Saccharomyces cerevisiae* in wine) would have used light and water energies to sustain life, and this capacity became the basis of all life. All plants, animals and humans sustain life through the electrical wiring of microbes in our digestive system, blood, etc. For example, the microbes use the subtle energies of negatively charged water and photons of light in human blood to sustain the vortex within blood to spiral around the 100,000 km of blood delivering arteries, veins and capillaries of the human body. Your heart is not a pump. The combination of heart rhythm and its internal structure of 4 chambers create the vortex that spirals blood around the body. Similarly, microbes will use the

photons of light trapped in wine to sustain their reproduction, exchange of DNA with other yeast species, and retain vitality.

The Chief Scientist of Phi'on (Robert Gourlay) has been researching fermentation techniques since the late 1990's. The one practice that has enabled the increase in microbial diversity and abundance is the reuse of the residue (known as a *starter culture*) collected from the tank-bottom of each fermentation. This residue contains the history of microbe DNA interactions that produces diversity. Similarly, many wine-makers in Europe and the USA use this practice to enhance the yeast diversity in the fermentation, along with the new wild cultures that arrive with a new batch of wines for processing. The process of increasing the diversity of yeast in the soil can be a major source of new, wild cultures for the grapes.

Clearly, it is the diversity of esters in wine (produced through microbial metabolism) that *tickles our taste buds* and we already know that wine flavours and tastes improve in a structured water form (the *evolutionary soup* of single celled microbes). Then it is probable that that restructuring the water in wine prior to, and after fermentation, increases the capacity or metabolism of the microbes (mainly yeast) to produce a diversity and abundance of esters.

Yeast in wine making

The role of **yeast in winemaking** is the most important element that distinguishes wine from grape juice. Yeasts convert the sugars of wine grapes into alcohol and carbon dioxide through the process of fermentation. The more sugars in the grapes, the higher the potential alcohol level of the wine.

The most common yeast associated with winemaking is *Saccharomyces cerevisiae* which has been favoured due to its predictable and vigorous fermentation capabilities, tolerance of relatively high levels of alcohol and sulfur dioxide as well as its ability to thrive in normal wine pH between 2.8 and 4. Despite its widespread use which often includes deliberate inoculation from cultured stock, *S.cerevisiae* is rarely the only yeast species involved in a fermentation. Grapes brought in from harvest are usually teeming with a variety of **wild yeast** from the *Kloeckera* and *Candida* genera. These yeasts often begin the fermentation process almost as soon as the grapes are picked when the weight of the clusters in the harvest bins begin to crush the grapes, releasing the sugar-rich must. The **Must** (from the Latin *vinum mustum, young wine*) is freshly crushed grape juice that contains mainly the skins and seeds of the fruit.

While additions of sulfur dioxide (often added at the crusher) may limit some of the wild yeast activities, these yeasts will usually die out once the alcohol level reaches about 15% due to the toxicity of alcohol on the yeast cells physiology while the more alcohol tolerant *Saccharomyces* species take over. In addition to *S. cerevisiae*, *Saccharomyces bayanus* is a species of yeast that can tolerate alcohol levels of 17–20% and is often used in fortified wine production such as ports and varieties at high *Brix* sugar levels.

Outcomes arising from yeast and structured water research

The article at the end of this essay, highlights several points:

1. Most of the fruity flavours in wine come **NOT** from the grapes, but from the chemicals called **esters** produced by the yeast's metabolism
2. Wine makers have learned that they could speed up a fermentation by adding a bit of the last brew or starter culture/brew
3. Wine yeast adapt to tolerate high alcohol levels and survive in the nitrogen-poor conditions, typical of fermenting grapes
4. The artificial selection pressures in the wine industry for yeast result in the loss of traits that help yeast survive in the wild. Consequently, artificial selection (absence of wild collection) result in yeast not coping with the natural variability in fermentation that exists because of variability in climate, weather, soil, sunlight, etc.
5. The continuous inclusion of wild cultures (eg. each year from grapes and through the cycling of starter cultures) will improve the yeast characteristics and reproduction capacity (including exchange of DNA between yeast species/sub-species)
6. The future in wine making will lie in the techniques of culturing yeast complexities into the wine (through yeast diversity) to produce new floral aromas.



The process of fermentation at work on Pinot noir. As yeast consume the sugar in the must it releases alcohol and carbon dioxide (seen here as the foaming bubbles) as byproducts.

When structured water with a **permanent negative charge** is used in wine production, the **pathogenic microbes cannot form to spoil the wine**. This strategy enables wine makers to be more adventurous in culturing wild yeast to increase wines *terroir*, the flavours that are prized by connoisseurs.

The link between structured water and health

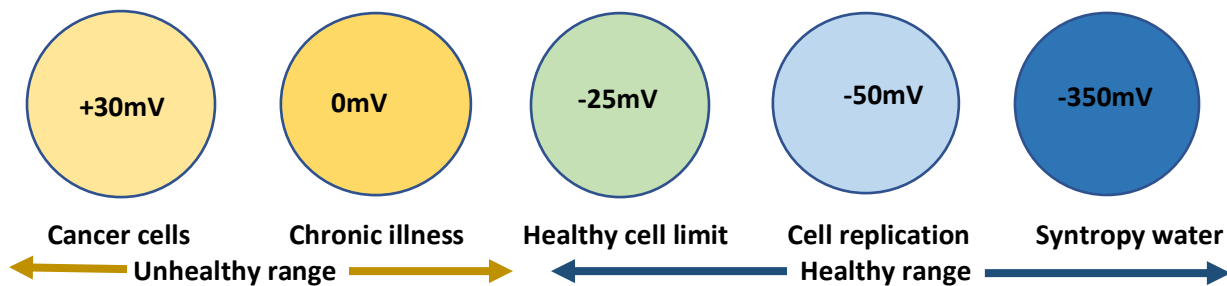
In 2012 Phi3n succeeded in developing a water conditioning device to produce structured water using a magnetic configuration to permanently hold a negative charge at -350mV . Some water scientists, including Schauburger, Grander and others have been able to structure water for limited periods of time but not for the long term (ie. more than 2.5 days). A mountain stream will carry negative charge at between -300 and -800mV due to its continuous vortexing

action and water turbulence. All healthy cells of the body work at -20 to -25mV (equivalent to a pH of 7.35-7.45) and cell voltage must rise to -50+mV to successfully make a new and healthy cell. Chronic illness occurs when voltage crosses from a negative (-) to a (+) positive charge. Cancer (and other chronic disease) starts at +30mV. The heart cells function uniquely and have a cell membrane potential of -110mV to -120mV. This is much higher than most cells that have a cell membrane potential of up to -70mV to -90mV. This voltage, along with salt enables heart rhythm and the blood to form a vortex that spirals through 100,000km of blood vessels of a human body. It is for this reason that the heart is **not** a pump (see Dr. Thomas Cowan's book *Human Heart Cosmic Heart 2016*).

Clearly, water is critical to cell function as it represents 70% or more of the body and blood is about 92% water. The science of water is relatively new and largely incomplete, however there is enough science to demonstrate that water with a negative millivolts charge is **life-affirming** (ie. in a syntropy form of energy) and sustains life. The cells of an injured part of the body will rise to a negative (-) 50mV to accelerate healing and make new cells. This change in polarity facilitates the movement of nutrients to the area that requires healing. **Therefore, we can assume that to heal the body you require a capability (ie. negatively charged cells and nutrient availability in the body) to deliver a negative charge (-) 50mV on demand.**

The key question arising from the above factors, that differentiates the **Phión MEA**, syntropy water device results from other technologies is the fact that the **MEA syntropy water retains its negative charge**. The only explanation is that the **MEA water device creates another time and space dimension to the six-sided crystalline structure that creates a permanent bond between the water molecules, and this prevents the exposure of the bonding to disorganisation**, eg. oxidation. That is, the MEA water is in a constant state of **syntropy** (energy accumulation and enhancing) that will sustain cells in a **higher function or order**.

Every cell on this planet operates at its fullest potential when the negative charge of the cell water (80% of the cell volume) is **-50mV or better**. When the cell charge falls towards a near positive (+) charge through cellular stress, due to poor diet (particularly access to nutrient dense food), poor lifestyle choices, exposure to radiation and chemical toxicity, then body organs and systems become diseased. See the diagram below.



Our ancestors have intuitively known through antiquity, the value of drinking and bathing in flowing, structured water. Therefore, they settled on flowing streams or springs, and consumed negatively (-) charged water every day.

The implication of low cellular charge is clear: our state of health is highly dependent upon the structure (negative charge) of cellular water. Nobel Prize Laurates, like Dr. Szent-Gyorgyi, Dr. Linus Pauling and Dr. Luc Montagnier were often quoted as wondering why the scientific and medical communities could not grasp this simple principle of the value of structured water to health and wellbeing.

Extensive research during the last two decades has revealed the mechanism by which continued oxidative stress (ie. cell loss of oxygen due to the loss of negative charge/electrons) can lead to chronic inflammation, which in turn means that drinking structured water (including re-structuring the water in wine: the percentage of water in wine is about 80-85% of the total volume) could mediate most chronic diseases including cancer, diabetes, cardiovascular, neurological and pulmonary diseases. The morale of this fact is that if you run out of electrons you are dead, and similarly if the soil does not have electrons sustained it will become dead.

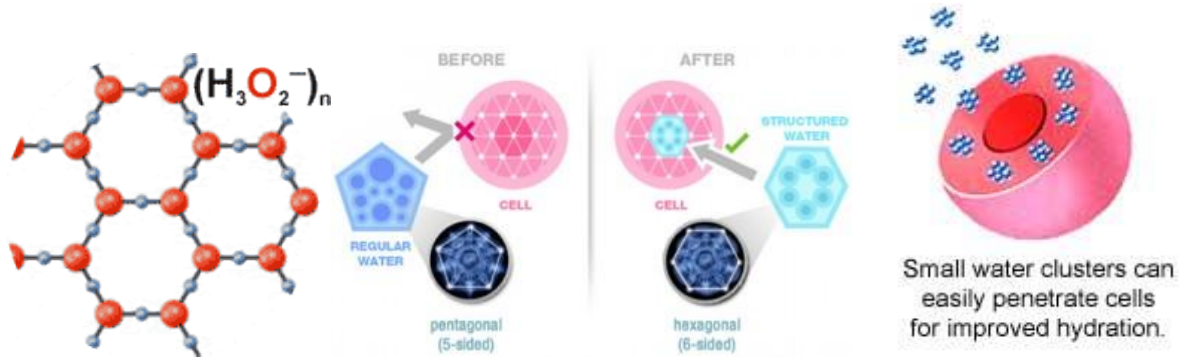
The fact that continuous irritation over long periods of time can lead to cancer had already been described in the traditional Ayurvedic medical system, written as far back as 5000 years ago. Rudolf Virchow (1821-1902) first noted that inflammatory cells are present within tumors and that tumors arise at sites of chronic inflammation (chronic irritation theory).

It was only towards the end of the 20th century that Virchow's theory was taken seriously. It was realised that specific cancers (including those of mesothelioma, lung, prostate, bladder, pancreatic, cervical, esophageal, melanoma, head and neck) are indeed strongly associated with long-term inflammation. However, the continuous use of medical drugs for inflammation can have adverse effects on body organs and systems.

During inflammation, mast cells and leukocytes are recruited to the site of damage, which leads to a *respiratory burst* and therefore an increased release from cells and accumulation of reactive oxygen species (ROS) at the site of cell damage. Inflammatory cells also produce soluble mediators, such as metabolites of arachidonic acid, cytokines and chemokines, which act by further recruiting inflammatory cells to the site of damage and producing more reactive species. This sustained inflammatory/oxidative environment leads to a vicious circle, which can damage healthy neighbouring epithelial and stromal cells and over a long period of time may lead to carcinogenesis.

The properties of structured water described by Pollack and coworkers overlap to some extent with those of water *coherence domains (CDs)* proposed by del Giudice *et al.* based on quantum field theory calculations. *Coherence domains* provide a *redox (ORP: Oxidation Reduction Potential) pile of quasi-free electrons*. This means that structured water itself can, and most likely does, function as an antioxidant to reduce ROS and therefore reduce inflammation.

Cell dehydration signs are not *always* obvious. Some surprising dehydration signs include fever, bad breath, and cravings for sweets. However, structured water helps to reduce cell dehydration because of the smaller clusters of $H_3O_2^-$, hexagonal water molecules that more easily penetrate cell membranes. See diagrams below (*Pollack, The Fourth Phase of Water*)



When alcohol is consumed, it passes from the stomach and intestines into the blood, a process referred to as absorption. Alcohol is then metabolised by enzymes, which are body chemicals that break down other chemicals. In the liver, an enzyme called alcohol dehydrogenase (ADH) mediates the conversion of alcohol to acetaldehyde. Acetaldehyde is rapidly converted to acetate by other enzymes and is eventually metabolised to carbon dioxide and water. Alcohol also is metabolised in the liver by the enzyme cytochrome.

Interestingly, the structured water in wine hastens the passage of alcohol to cells (ie. feeling of alcohol effects earlier). However, the structured water in wine also hastens the metabolism of the alcohol so that it is detoxified and removed from the blood faster, thereby preventing the alcohol from accumulating and destroying cells and organs.

Structured water and biology applications in grape production

Research by Resonate Research since 2012 has demonstrated that the negatively charged water produced by the MEA water conditioner devices has a natural and unique association with microbes (eg. soil water, and the gut of animals and humans) in the transport of nutrients. That is, when negatively charged water is added to soil biology, the uptake of nutrients to a plant can be 2-4 folds greater. Resonate Research has measured at least a doubling in food production.

For example, the images (page 20) of the vineyard (Half Moon Vineyard, Mongarlowe, NSW, Australia) show very healthy plant foliage albeit that they grow on very poor soils with low nutrient availability. The size of plant leaves trebled, and grape bunches doubled in size along with grape numbers. Consequently, grape tonnage doubled (from 5 to 10 tonnes) in 2013 due to the use of a 2" water conditioner and the application (fertiligation) of Resonate Research soil biology (Catalyst) to the water. There was no loss in grape juice quality.



In the images below, the application of structured water and biology during the early stages of fruit growth had a knock-on effect in the growth of clover between the rows.

These results validate the value of increasing soil microbial diversity through fertigation and delivering the microbes in a water with a permanent negative charge. This combination is particularly important to soil microbial balancing, promoting growth and plant resilience, and preventing fungal infestation. This resilience is then carried through the wine making process and is evident in the wine quality (eg. preserving, flavour and aging effects)

Similar results have been achieved with home grown table grapes, eg:



The image on the left is a bunch of table grapes grown with MEA water and containing 375 grapes.

Initiatively, most grape growers would think that increased yields like the grape sizes above, with the use of structured water and biology would decrease flavours. However, this is not the case. In fact, in the case of the Half Moon vineyard, the Riesling continues to win medals in the Canberra Wine Show. Also, the increase growth through photosynthesis has many knock-on effects for the vineyard sustainability, ie:

1. Increased photosynthesis produces more carbohydrates for the soil biology that increase microbial diversity and abundance, and hence increases soil carbon and the uptake of nutrients to the plant
2. Increased soil carbon enables better soil water storage and therefore less water use, and drought protection
3. The larger plants and leaf sizes provide a sun shade protection to the grape bunches and this minimises fruit burn
4. Healthier grape vines have less insect attack due to the increased carbohydrates in the fruit and leaves.
5. The increased diversity and abundance of soil microbial activity reduces fungal infection and provides greater resilience to the plant over time
6. Increased yields increase the potential for increased profitability.

The reason these results are possible is largely based on the science of the synergistic relationship between a plant, the soil and sunlight, albeit that multiple environmental factors are indirectly involved in plant health and resilience.

A 2018 report from the University of Bristol's School of biological Sciences has discovered that plants adjust their daily circadian rhythm to the cycle of day and night by measuring the amount of sugars in their cells. In fact, animals, plants, fungi and some bacteria can estimate the time of day through their circadian rhythms. The sugars in plants are made from photosynthesis and these sugars are sensed by the plant and this leads to the plant falling into rhythm with changes in energy provision throughout the day.

In the case of grapes, every species has an inbuilt (genetic expression) daily circadian cycle that is affected by day length and temperature. Grapes will sum heat in a process called Effective Heat Degree Days (EHDD) through its circadian cycle and this leads to the timing of maturation. Empirical evidence suggests that plant phenology and production can exhibit interdependence (plant phenology relates to the timing of the biological events in plants such as leafing, budding, flowering, reproduction or fruit production, etc).

However, studies by Phi'on (see examples on pages 12 and 13) have demonstrated that:

- The amount of photosynthates that a plant produces is highly governed by the soil health (the products of photosynthesis are called photosynthates, which are usually in the form of simple sugars such as sucrose), and soil health is highly dependent on a wide diversity and abundance of soil microbes, minerals and other nutrients, high soil carbon levels, water storage capacity and water structure (ie. water with a negative charge)
- When a plant senses (awareness of consciousness of environment) a high level of sustained soil health the plant will adjust its circadian rhythm to maximise photosynthesis and thereby increase the stored and distributed carbohydrates (sugars or exudates distributed to the roots as food for microbes) This process is classic

syntropy energy produced by the **synergistic relationship between a plant and soil microbes**

- A plant with a high acquisition rate of photosynthates is then capable of adjusting its timings for budding, flowering and fruit maturation. Photosynthates, such as sucrose, are produced in the mesophyll cells of photosynthesising leaves. The photosynthates are then translocated through the phloem to where they are used or stored. The plant can then call on its *sugar pantry* to adjust for an earlier start to budding and a shorter time to fruit maturation. In the case of grapes, this can mean the difference between fruit harvest and fruit lost to frost
- The plant continuously senses the amount of sugar in its cells and uses this information to adjust **energy flow** to maximise growth and reproduction (including fruit yield, fruit integrity/quality, and resilience to disease).

Conclusion

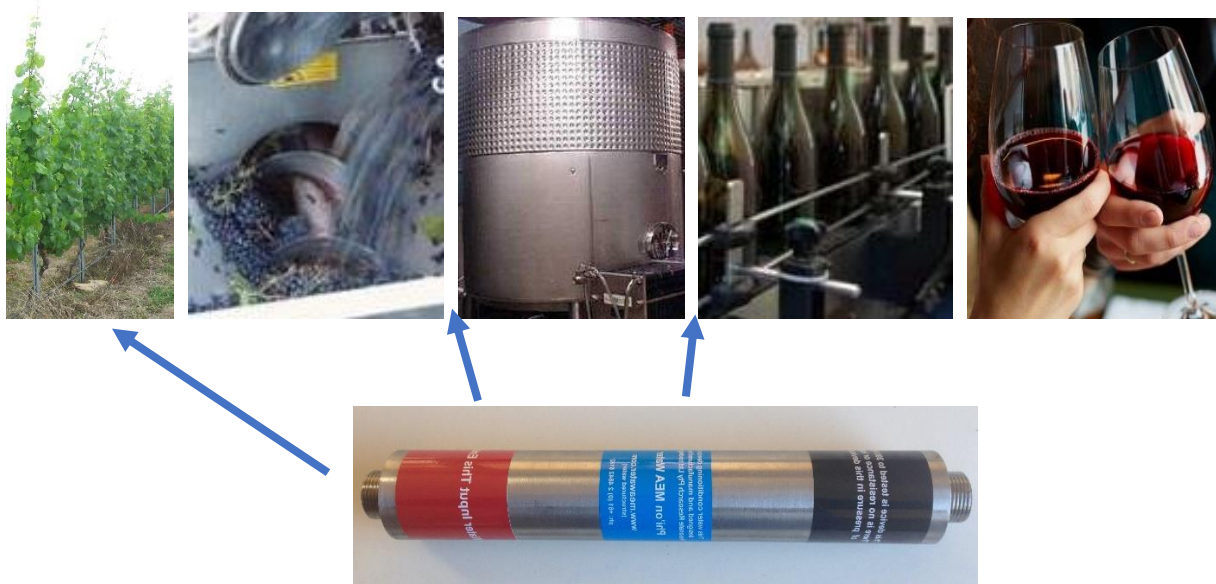
Wine value has been shaped both by innovation and fashion over the course of several thousand years. The earliest records of wine production go back to **7,000– 6600 BC** in China. Consequently, you can learn a lot about life by understanding how wine has changed over the course of history, and through many cultures around the world. Wine values have evolved over time and this process will continue with new innovations. This paper outlines innovations developed by Phi'on (Resonate Research Pty Ltd) to improve wine production and enjoyment.

Phi'on has been testing MEA water devices since 2012, and the results indicate a strong **epigenetic** (environmental) influence of the structured (negatively charged) water on soil microbes (biology) and plants, especially important for microbial activity becoming multi-generational (diversity). That is, there was a significant effect of the presence of the MEA negatively charged water (ie. like thunderstorm water) on plant growth, eg. uptake of soil nutrients to the plant. Consequently, the combination of microbes and negatively charged water are the life forces within the soil, breaking down the nutrition in the soil into forms digestible by the plants. If microbes aren't flourishing in the soil, plants will not properly grow, and will become disease-prone and susceptible to viruses, fungus and insect invasion. There is clear evidence from research trials by Phi'on that soil health is significantly improved when **structured, negatively charged water is added to microbial formulations**, and sprayed onto the soil and plants (including seeds and seedlings).

Structured water is responsible for the stability of healthy DNA in a cell. When a cell begins to lose its crystalline structure (due to illness or aging), DNA integrity of the cell is often compromised and light emission from the nucleus is either diminished or excited (a state of disharmony or incoherence). The integrity of cellular water is essential for good health or body regulation and healing. Any disease means that proteins are not working in that organ, and the water inside the cell, and near the protein, is not in a structured form. That is, the potential of

the Krebs Cycle to generate the precursors of amino acids and lipids to build proteins, and therefore produce energy; has been compromised.

Since the story of wine starts in the soil and ends with the enjoyment of drinking, then wine innovation must have an end-to-end process of integrated technologies. All research in Phi'on has a primary focus on food from the soil to the palate. In the case of wine, the process looks like this (images on next page):



In the above process a Phi'on MEA water conditioner provides a negative charge to;

1. Deliver the soil biology as fertigation and activate the soil microbes with the (-) charge
2. The grape juice is pumped through an MEA device to the fermenter. This ensures that the beneficial yeasts are potentiated, and the wine is protected from spoiling
3. The finished wine is pumped through an MEA device from the fermenter to the bottling process to ensure that the wine is bottled with a permanent negative charge.



If the wine has not been treated by the winery with a MEA device, then the consumer of the wine can pass the wine through a MEA bottle top device and store the wine in a wine carafe.

In the longer run, the one thing we can be sure of is that structured wine that has a negative (-) charge will:

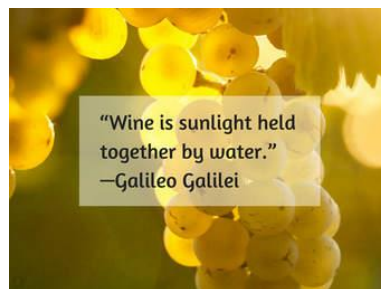
1. **Never oxidise** and turn to vinegar
2. Be **healthier for human cells** (ie. the negative charge on the water in the wine)
3. **Improve in complexity** over time (aging)

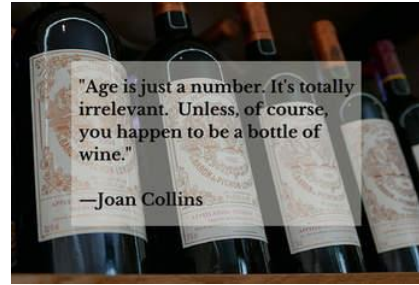
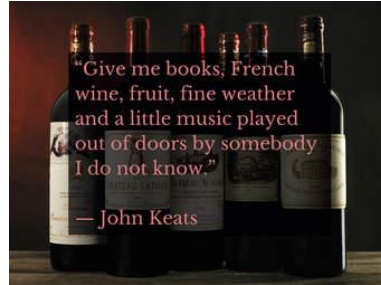
Many people have participated in wine tasting and selected been wine A and wine B. Phi'on has carried out this experiment many times to test whether people prefer a wine that is not treated with the Phi'on bottle top device (A) and a wine that has been treated with the bottle top device. In a statistically significant number of cases (ie. better than 85%) people select the wine that has been **treated with the bottle top device**. This % improves if the wine is left for 1 hour at least before tasting, and biodynamic and organic wines show the greatest differences over time. That is, biodynamic and organic wines have a greater potential to express flavour when the wine's water holds a permanent negative (-) charge.

Since wine consumers are becoming more aware of food and beverage integrity, there will be a greater focus by these consumers on products that present information about the quality in grape production and wine processing.

There are now new technology opportunities in grape production, wine processing and wine presentation that enable biodynamic and organic wine makers to seize the marketing opportunity with a new story about **wine quality**. Wine is primarily consumed for enjoyment in the company of others and this enjoyment is enhanced if the wine is healthier than other wines.

This paper brings together the new technologies in the use of wild yeasts for wine fermentation, and the values in restructuring the water in the wine to hold a permanent negative (-) charge. These two facets of wine making will be the new frontier in wine making that will kick-start biodynamic and organic wine consumption for health and enjoyment.





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Note: In Latin, *mea*=my. *meawater*=my water.

New Scientist Article: Our true best friend, 18 August 2018

FLORIAN BAUER'S recipe doesn't sound very wine-like. Take water, sugar, some amino acids and yeast, and let it ferment. And yet... "When you smell it you say, 'yes, that's wine!'," says Bauer, a wine scientist at Stellenbosch University in South Africa.

Most people would casually assume that a wine's nose is all about the grapes, just as a beer's flavour is all in the hops and barley. Not so. Much of the taste of these beverages comes from an organism too small to see with the naked eye. From a sugar-loving fungus, to be precise, one we use to produce not just wine, beer and sake, but also bread, some of our most toothsome cheeses and more.

Unwittingly at first, we have been domesticating and breeding this single-celled organism for millennia. The resulting legion of faithful servants can claim, arguably more than any dog, to be humanity's best friend.

We're talking about yeast – or more precisely *Saccharomyces cerevisiae*, or brewer's or baker's yeast. But while yeast's fermentative properties are well known, we are only now getting to grips with just how much it contributes to flavour. As researchers prise open its secrets, they are finding new and sometimes truly weird ways to tickle tipplers' and gourmands' taste buds. Beer like banana milkshake? Bread with a truly nutty crunch? With yeast, everything is possible. "In terms of flavour, you can go as far as your mind can take you," says Jan Steensels, a molecular biologist at the Flemish Institute for Biotechnology (VIB) in Belgium.

We have been fermenting stuff for thousands of years, but most of that time we knew nothing of the existence of *S. cerevisiae*. Fermentation was something that happened almost magically. We now know it happens as yeast feeds on sugar, converting it into ethanol, the intoxicant people seek out in beer and wine, and carbon dioxide, the gas that gives leavened bread its airiness.

Brewers and bakers quickly learned that they could speed the process in an unfermented batch by adding a bit of their last brew or starter dough. Over the centuries, this repeated nurturing has shaped the evolution of yeast strains that are finely tuned for their purpose. Beer yeasts adapted to the mix of sugars in fermenting beer, and the ones that produced a pleasing flavour profile survived and prospered. Wine yeasts adapted to tolerate high alcohol levels and survive in the nitrogen-poor conditions typical of fermenting grapes. Cheese yeasts, present on the surface of cheeses such as Brie and Limburger during ripening, evolved to use the milk sugar galactose. And so on.

Cats and dogs

The process played out a little differently in each case. The artificial selection pressures of the brewery meant that beer yeasts gradually lost traits that helped them survive in the wild. Most can no longer reproduce sexually, for example, losing an important strategy for coping with variable natural environments. But because wine is made only in autumn, wine yeasts had to bide their time on vegetation or winery equipment for the rest of the year. They have retained more of their wild characteristics, including sexual reproduction. "Beer yeast is more like dogs, while wine yeast is more like cats," says Steensels. "Cats can survive in the wild, but if you put a chihuahua in the jungle, it wouldn't survive."

Steensels was part of a team that in 2016 sequenced the genomes of 157 strains of *S. cerevisiae* and built a family tree. They found there were separate branches for wild strains, wine yeasts and Asian sake yeasts. Beer yeasts occupy not one but two branches, each of which traces back to a common ancestor just 500 or so years ago, about when industrial brewing supplanted home brewing. Bread yeasts are part of a mixed group most closely related to the main beer group.

“Beer yeast is like a chihuahua – it wouldn’t survive in the jungle”

The family tree paints a picture of a domesticated organism pumping out alcohol and carbon dioxide as its main job. Yet as Bauer’s unpublished wine-spoofing experiment shows, this is far from all that yeast does. Most of the fruity flavours in wine come not from grapes, but from chemicals called esters produced by the yeast’s metabolism. Beer generally contains no fruit at all. Most of its flavour notes – floral, banana, pear, whatever – come from yeast-derived esters. Yeast also accounts for a wide range of other small, volatile molecules that contribute to the aroma of the final product. Wine-makers and, increasingly, brewers can select specific strains from yeast suppliers to achieve the desired sensory profile in their finished product.

We know surprisingly little about why yeast bothers to make these volatiles. One theory is that they are accidental leftovers discarded as the yeast produces cell membranes and other key materials. This unimportance would explain why different yeast strains, or the same strain under different environmental conditions, can produce very different mixes of volatiles.

There is an alternative explanation, and it comes from ripe fruit. Just as with beer and wine, many of the smells we commonly associate with fruit are not, in origin, fruity. “If I leave a banana in my office, which I often do, it’s pretty obvious when I come in on Monday morning that there’s a banana there,” says Brian Gibson, a yeast biologist at the VTT Technical Research Centre of Finland. “That’s the yeast contribution, not the banana itself.”

Those yeasty smells notoriously attract flies. Yeasts are relatively large, heavy microbes, and cannot easily drift from host to host on the breeze. But producing sweet-smelling chemicals might attract insects to hitch a ride on – and help disperse yeasts to new habitats.

Sure enough, in 2014, a team led by Kevin Verstrepen at VIB showed that volatile acetate esters produced by yeast do attract insects. That same year, Matthew Goddard, then at the University of Auckland, New Zealand, and his colleagues showed that yeast strains more attractive to fruit flies are more likely to be dispersed. But Goddard remains unconvinced that most volatiles are there as dispersal aids – if they were, every yeast strain would have evolved to produce the optimal mix, he says.



Yeast cultured in the lab to make new flavours

Whatever the reason for making volatiles, their diversity is a boon for yeast breeders. In 2014, a brewery asked Verstrepen's team to develop a yeast that produced more of the banana and pear-like esters prized in Belgian-style beers. The researchers found that existing yeast strains varied 34-fold in how much of these esters they made. After picking three of the top producers and cross-breeding them, using some genetic tricks to ensure sexual reproduction, they quickly boosted the ester production of the best-performing strains by 50 per cent.

Similar breeding programmes could soon enhance the taste of two types of beer that often leave a little to be desired: lagers and non-alcoholic beers (see "[More yeast, more fun](#)"). Not every novel yeast needs special breeding, however; many are out there waiting to be found. Home brewers along western Norway's fjords, for example, have been handing down their own yeast for generations. Genetic studies suggest that these *kveik* yeasts are distinct from the main beer-yeast lineage. They produce a distinctive flavour profile that includes desirable tropical fruit notes and even an intriguing, as yet not fully characterised, mushroom-like savour. "I find them to be quite different from other domestic yeasts," says Richard Preiss, a microbiologist and co-founder of Escarpment Laboratories, a company based in Guelph, Canada, that markets *kveik* and other regional yeast strains to breweries. "I can usually pick *kveik* out of a herd," says Preiss.

Many wine-makers have travelled this path already, fermenting their wines with wild yeasts that settle on the grapes naturally. Since the yeast flora varies from vineyard to vineyard, this can contribute to a wine's terroir, the flavour of place so prized by connoisseurs. Brewers of Belgian lambic beers claim the same of the seasonal wild yeasts of the Zenne valley. Bakers have fewer options. Speciality bakers do often develop richer flavours in their loaves by using sourdoughs, fermented by whole communities of yeast and bacteria. But flavour diversity traditionally has not been as important in bread-making: even high-end bakers have had no options for ordinary leavened loaves other than bog-standard bread yeast.



Yeasts have come a long way from their wild cousins on the surface of grapes

Verstrepen's research suggests that may be a missed opportunity. His team baked test loaves with 10 non-standard yeasts: two *Saccharomyces* species and eight species from other genera. Most either failed to leaven the bread enough or produced unpleasant and potentially toxic by-products. Two species, however – champagne yeast *Saccharomyces bayanus* (thought to be a three-way hybrid between *S. cerevisiae* and two related species) and *Torulasporea delbrueckii*, used to produce Chinese liquor – showed both good leavening and unusual, subtly nutty or fruity notes that tasters found pleasing. These yeasts could someday give commercial bakers new options, the researchers say.

Over the centuries, we have done well in expanding yeast's repertoire of tricks, by exploiting its natural diversity and breeding and selecting strains with desirable traits, first accidentally and then on purpose. Genetic methods are now upping the game. Verstrepen, for example, has produced genetically modified yeasts that make so much of the banana-flavoured isoamyl acetate that the resulting ale tastes more like banana milkshake. That may sound yucky, but it shows what's possible. As yet, no conventional breweries are keen to use GM yeast, for reasons of consumer acceptability.

Unleash the inner yeast

We can do similar things without cutting and pasting DNA, though. When Christopher Curtin and his colleagues at the Australian Wine Research Institute near Adelaide wanted a wine yeast that would contribute rose-like floral aromas, they noted that the volatiles responsible are derived from the amino acid phenylalanine. What they needed, therefore, were cells that produced phenylalanine more readily. So they added a toxic analogue of phenylalanine to a yeast culture, figuring that cells that would keep making the amino acid instead of taking up the toxin would be more likely to survive.

It worked: their strategy created several lineages of yeasts with high-activity mutations in two genes that are part of the metabolic pathway for making phenylalanine. The yeasts produced up to 20 times more of the rose aromas, and this led to pleasingly floral white wines. "It has a big impact on aroma," says Curtin, who is now at Oregon State University. Yeast companies are already working to commercialise the new strains.

And it is just the start. Yeast may be one of our littlest pets, but its metabolism is complex. Breeding to favour one pathway often has unexpected knock-on effects on others, and we don't yet understand enough to shape entire flavour profiles in a predetermined, pleasing way.

For the yeast whisperers, then, there is still much to achieve. "That's good," says Verstrepen. "It stays a bit of an art."

More yeast, more fun

Few questions animate beer lovers so much as why lager tastes so samey and non-alcoholic beer so rubbish. The answer is simple: yeast.

Low or no-alcohol beer is made in one of two ways. You can stop fermentation early, yielding less alcohol but also fewer of the pleasing yeast-derived flavours. Or you brew normal beer and then remove the alcohol – and many of those same flavours along with it.

Kevin Verstrepen of the Flemish Institute for Biotechnology (VIB) in Belgium and his team say they have solved the problem, by breeding a yeast strain that produces a pleasing flavour spectrum even after the alcohol and some volatiles are removed. "To be honest, we are now beyond this," says Verstrepen, but non-disclosure agreements – presumably with brewers – prevent him from telling more.

A second option is to work with yeast species beyond the usual *Saccharomyces cerevisiae*. "Saccharomyces have been designed by evolution to produce alcohol. It's kind of their party trick," says Brian Gibson at the VTT Technical Research Centre of Finland. Other yeasts are less boozy and yet produce pleasing flavour profiles. Already, some German brewers are using *Saccharomyces ludwigii* – a wild yeast more usually associated with food spoilage – in their low-alcohol brews, and other yeasts are being studied. At the other end of the spectrum, yeast that naturally makes a higher-alcohol, more intensely flavoured beer could yield environmental benefits, says Verstrepen. Brewing such a beer and diluting it back to normal strength would let brewers make the same amount of beer in a smaller brewery using less energy.

And what of lagers? The problem there is that they are fermented cold, something *S. cerevisiae* does poorly. Lager yeasts are hybrids of it and the related wild yeast *Saccharomyces eubayanus*, which has been found in Tibet and Patagonia and contributes cold-tolerance. All lager yeasts are descended from just two such hybrids created about 500 years ago, presumably in Bavaria. Lager yeast underwent another genetic bottleneck in the 19th century, when the Carlsberg brewery in Copenhagen began culturing specific strains. This lack of genetic diversity is a big reason that most lagers taste so similar to one another.

To broaden the flavour palette, in 2015, Verstrepen's student Stijn Mertens created 31 *cerevisiae*–*eubayanus* hybrids. Many of them made terrible beer with unappealing onion or clove flavours, but a few gave more pleasing fruity tastes not usually found in lagers. The new yeasts are now being developed for commercial use, says Mertens.

Verstrepen's team is also working on a way to speed up yeast breeding. By encapsulating individual yeast cells in water droplets in an oily matrix, they can now screen hundreds of thousands of crosses at once. "We often call them single-cell breweries," says Verstrepen.

A short story on Esters and Aldehydes by Russell Moss

Introduction

This article is one of a series which covers the fungal and bacterial origins of wine aromas. These articles detail esters, aldehydes, volatile fatty acids, volatile phenols, sulphurous compounds and higher alcohols. The old-adage *one man's trash is another man's treasure*, holds true with these compounds.

A winemaker may make a Sauvignon blanc table wine within which they would like to have dominant aromas of grapefruit, gooseberry and passion-fruit and perceptible acetaldehyde would be viewed as a fault. However, another winemaker may wish to make a wine that emulates sherry, at which point maximising acetaldehyde production would be intrinsic to the style of the wine.



Russell Moss

The same is also true with esters. A winemaker may wish to create a young wine that is similar to Beaujolais Nouveau or a fresh white wine that is meant for immediate sale. In these cases, the formation and retention of esters during fermentation will be critical to wine style. Another *vigneron* may wish to make a Pinotage table wine that has deep flavours of smoke, earth and a varied assortment of berries. In this case, the winemaker might view isoamyl acetate (an ester) as a fault and attempt to minimise its impact on their wine by controlling viticultural and winemaking practices which will influence this compound.

Esters

Esters are the class of volatile compounds that are responsible for a general “fruity” smell in wines. They are some of the most abundant aromatic compounds within wine (Pretorius & Lambrechts, 2000). Esters are found in grapes in small amounts, but most of the esters in wine are formed during fermentation or during wine ageing. Esters can be classified as either volatile esters (or neutral esters) and acid esters (or non-volatile esters). The neutral esters are produced through enzymatic reactions; acid esters are formed in simple hydrogen-ion-catalysed esterification (Margalit, 2004). This simple acid catalysed reaction is slower than enzymatic esterification but may be responsible for aged characters of wine. Additionally, acid catalysed esterification may occur faster in wines of a lower pH (Edwards *et al.*, 1985). Therefore, esters not only contribute significantly to the sensory impact of newly fermented wine, but the aged product as well.

Volatile esters are produced in such high quantities during fermentation that the concentration surpasses the synthesis/hydrolysis equilibrium point, and they cannot be maintained. During ageing, volatile esters decrease as they react hydrolytically and finally achieve equilibrium (Pretorius & Lambrechts, 2000). Non-volatile esters contribute relatively negligible aromas and flavours in wine however they may somewhat soften the tartness of highly acidic white wines such as those hailing from Chablis (Margalit, 2004). Volatile esters are a major component of fermentation bouquet and rapidly dissipate after fermentation (Boulton *et al.*, 1996). Therefore, wines such as those famous in Germany around fall, *Federweißer* also known as *neu wein*, rely heavily on fermentation esters as they are wines in which fermentation was stopped and bottled for quick sale.

There are two groups of esters, namely aliphatic and phenolic. Only the aliphatic monocarboxylic esters make a significant impact in wine. The monocarboxylic acid esters can be further broken down into those formed from ethanol and saturated fatty acids. The second group are those formed from acetic acid and higher alcohols. It is true that the monocarboxylic acids are the most significant esters for most wines, however meth- and ethanolic esters have been found to be associated in the aroma of Muscadine wines (Lamikanra *et al.*, 1996). The physiological function of esters formed during fermentation is unclear (Pretorius & Lambrechts, 2000).

Esters can arise in two ways: from acetates, ethanol and higher alcohols or from ethanol and straight chained fatty acids. Esters which form from acetates, ethanol and higher alcohols include:

- Ethyl acetate, isobutyl acetate, isoamyl acetate and 2 phenethyl acetate.
- Esters which form from ethanol and straight chain fatty acids include: Ethyl hexanoic acid, ethyl octanoic acid and ethyl decanoic acid.

The esters formed from fatty acids are not nearly as important in wine production as the acetate esters. They are more significant in products of distillation (Zoecklein *et al.*, 1999).

The mechanism by which yeasts form esters has been theorised by many, but a consensus has not been reached. Some believe that the reaction is catalysed by an enzyme called alcohol acetyltransferase (AAT). This reaction uses alcohol (as a substrate), co-enzyme A and ATP to form an ester (Boulton *et al.*, 1996; Mason & Dufour, 2000; Zoecklein *et al.*, 1999). Esters may also be formed through simple hydrogen-ion-catalysed reactions.

Oenococcus oeni and other lactic acid bacteria have esterases and can affect the ester concentration of a wine during malolactic fermentation. This is done through either ester synthesis or hydrolysis, which will complement or detract from wine aroma, depending on the esters produced or metabolised by the strain (Davis *et al.*, 1985).

Esters are usually associated with “general fruit” rather than attributing a specific aroma; however, they are not always pleasant (e.g. ethyl acetate) (Pretorius & Lambrechts, 2000;

Zoecklein *et al.*, 1999). Ethyl acetate, which has a detection threshold of 12 – 14 ppm, is also present in acetic acid and contributes to the vinegar (or nail polish) aroma at 120 – 160 mg/ℓ. The perception of VA as a fault is a function of the ethyl acetate:acetic acid ratio (Margalit, 2004; Pretorius & Lambrechts, 2000).

Esters are generally thought to be more important to the aroma of white wines; their significance in red wine aroma is less understood. Esters are critical in the production of Pinotage wine. If uncontrolled, this variety develops a pungent, banana aroma from isoamyl acetate, which is not only produced during fermentation, but also found within the grape itself (Van Wyk *et al.*, 1979). Esters can be a major contributor to varietal aroma as well. This is especially true in Pinot noir from Burgundy, which contains four esters that contribute to its characteristically fruity aroma (Moio & Etievant, 1995).

Native yeasts such as *Hansenula anomala* and *Kloeckera apiculata* produce an abundance of ethyl acetate. Therefore, yeast strain can affect the formation of certain esters. Lema *et al.* (1996) found that the concentration of total esters was more dependent on the size of the initial yeast culture, rather than the yeast strain itself. However, the concentration of the esters produced was different from strain to strain. *Saccharomyces* yeast generally produce roughly the same concentrations of esters, but their distribution differs. Non-*Saccharomyces* yeast can produce many more esters than *Saccharomyces* but may not always be pleasant. Nonetheless, this may be a reason why natural fermentations produce wines of greater complexity (Boulton *et al.*, 1996).

Volatile esters are an important component of the fermentation bouquet, and they rapidly dissipate after fermentation (Boulton *et al.*, 1996). Further, must conditions, such as high solids and high fermentation temperatures (>15°C), can decrease the number of potential esters formed during fermentation (Boulton *et al.*, 1996; Margalit, 2004).

Aldehydes

Acetaldehyde constitutes around 90% of all the aldehydes found in wine. It is a normal yeast fermentation by-product and is an intermediary in the process of diacetyl forming from pyruvic acid (Pretorius & Lambrechts, 2000).

Acetaldehyde is the penultimate compound produced during the conversion of sugar to ethanol. Sugar is metabolised through glycolysis, which allows for the formation of ATP and NADH, providing cellular energy. The product of glycolysis is two pyruvate molecules. Pyruvate is then enzymatically decarboxylated to form acetaldehyde. Acetaldehyde is then enzymatically converted to ethanol. Not all the acetaldehyde produced by the yeast cell is converted to ethanol, as it is used to maintain a redox balance within the cell. Therefore, some of the acetaldehyde remains in the cell, some is excreted, and the rest is converted into alcohol. Notably, ethanol can oxidise back into an aldehyde (Swiegers *et al.*, 2005). Acetaldehyde can also increase in wine through enzymatic oxidation of ethanol by film yeast. These yeasts utilise ethanol as their primary carbon source for growth. Film yeast are regularly exploited in the

production of sherry but must be controlled when creating table wine. Further, yeast differ widely in their ability to produce acetaldehyde. In general, low acetaldehyde-producing yeast generate less acetic acid and acetoin than their higher-producing cousins (Romano *et al.*, 1994). Therefore, these yeasts can be selected to create a *more-fresh* wine style. Cellar temperature during bulk wine storage is critical for the control of film yeast. Temperatures of 8 – 12°C are ideal for restraining oxidative yeast film formation (Zoecklein *et al.*, 1999).

Aldehydes commonly convey a nutty or bruised apple aroma (Swiegers *et al.*, 2005). This compound is intrinsic to oxidative wine styles, such as sherry and *Vin jaune* (yellow wine); however, where these characteristics are desired in these styles, they are viewed as a fault in typical table wines. In fact, where aldehydes are intrinsic to the Savagnin dominant *Vin jaune* wines of Jura, aldehydes in the *Vin de paille* (also Savagnin dominant) wines from this region, would be viewed as a fault.

Besides affecting wine aroma, aldehydes may be intricately linked to colour development of red wines. Aldehydes interact with phenolic compounds during wine ageing, which promotes the formation of tannin-anthocyanin polymerisation. The role of acetaldehyde in wine colour stability may be of little to no significance (Somers & Wescombe, 1987; Timberlake & Bridle, 1976; Swiegers *et al.*, 2005).

Free acetaldehyde in young wine is usually less than 75 ppm. Although, if oxidative reactions induce higher acetaldehyde concentrations then SO₂ is used to neutralise the aromatic impact of acetaldehyde and form the less aromatic product, acetaldehyde- α -hydroxysulfonate (Zoecklein *et al.*, 1999). It requires 1.45 mg of SO₂/mg of acetaldehyde for the latter to be completely “bound” (Hornsey, 2007). Unfortunately, SO₂ is not always a positive tool in decreasing the sensory impact of acetaldehyde. Increasing amounts of pre-fermentative SO₂ correlates with higher acetaldehyde production, since SO₂ inhibits aldehyde dehydrogenase, which converts acetaldehyde to ethanol (Frivik & Ebeler, 2003; Ribereau-Gayon *et al.*, 2006). Further, incorrect timing of the SO₂ addition leads to the degradation of acetaldehyde- α -hydroxysulfonate by lactic acid bacteria, thereby releasing SO₂ and halting, or prolonging, malolactic fermentation (Osborne *et al.*, 2000).

Conclusion

Wine is commonly referred to as a *complex matrix* and this is certainly true. However, by breaking wine down into its fundamental components, we can begin to understand how to better manage our vineyards and wineries to attain the wine styles that our markets desire. Esters and aldehydes could be considered a fault or aromas that are intrinsically valuable to our wine style, depending upon what we are trying to achieve. To this end, it is crucial to understand how these compounds arise and how vintners can manage them effectively and efficiently.