Declaration

I, Wanda Hendrina Cronje, declare that this research report is my own, unaided work. It is submitted in partial fulfilment of the requirements for the Diploma of Cape Wine Master to the Cape Wine Academy. It has not been submitted before for qualification of examination in this or any other educational organisation.

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Signed **12 February 2020**

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Anika Lombard, office manager at Sadie family Wines

Eben Sadie, winemaker at Sadie family Wines

Elsie Pells, CWM

Johan Gotze, husband

Justin van Wyk, winemaker at Constantia Glen

Krige Visser, winemaker at Arganceli and best coffee barista

Lisa du Toit, owner Urban Wine

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Nadia Barnard, winemaker at Waterkloof Wines

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Pieter de Waal, winemaker at Hermit on the Hill

Tim Elphick, winemaker Portsea Estate, Australia

Willem Cronje (1947-2019), my father

God, for giving me the patience for this journey

Contents

1. Background

Wines ferment and age in many different types of vessels, from stainless steel tanks and amphora to vats of wood, concrete or plastic, and several other options. The decision to which vessel to use depends on the style of the wine, budget, or materials at hand. The choice is evident in the finished wine. There is an international movement toward using alternative winemaking and maturation vessels, such as concrete and stone wine eggs, terracotta amphorae, ceramic and even high-density food-grade plastic. The first modern concrete wine egg, commissioned from Nomblot, was used by Chapoutier in France in 2001. This modern egg marked the start of a new era with winemakers experimenting with and accepting not only cement eggs but also ovoid and square vessels made from plastic, ceramic and clay. Generally, winemakers believe these eggs produce wines with more depth, as quoted by Anna Matzinger of Archer Summit in Oregon, "What the egg offers is this fascinating textural depth, and then you still get the precision of what you might get in stainless steel fermentation" (Meisner, 2016).

Manufacturers use different materials to produce these eggs. Winemakers differ as to what type of other fermenters to use for what kind of wine. "There are a million factors at play, including climate and the intended wines, but in the end, it is about careful choice and the willingness to experiment " (Calvert, 2017).

South Africa has embraced this winemaking trend and some of the benefits it offers:

- Local manufacturers
- More ecologically sustainable, as fewer trees are cut down
- Longer lifespan in comparison to barrels.

From a non-winemaking perspective, the bulbous shape compares well with dinosaur eggs or alien creatures, and this evokes interest from the visitor to a winery that has concrete wine eggs as wine fermenters or maturation vessels. The cement eggs might be the 'new best thing' from the winemaker's perspective, but for a visitor to a winery where these eggs are visible, it contributes to the wine and the whole experience. The eggs are a talking point, and the tactile nature adds to what might have been just another visit to a wine farm.

2. Outline

Eben Sadie asked: "What is an honest wine? A wine that resonates the space, more than anything else. A true African wine is made from African grapes, in a cellar here; why then add France by putting it into a new barrel?" (Sadie, 2017). Some winemakers take it even further. Château Pontet-Canet in Bordeaux added some of their terroir into their concrete tanks by blending soil from the property into the concrete mix. Yogi de Beer used clay from Avondale to make amphorae used for wines at Avondale. Critical thinkers in South Africa who move away from stainless steel and new oak, include Eben Sadie, Jonathan Grieve, Duncan Savage, Justin Van Wyk, Karl Lambour, Krige Visser, Natasha Williams and Nadia Barnard, amongst others. All agree that wine should represent its domain, and this includes using neutral vessels with the benefit of micro-oxygenation and the exclusion of vanillans and lactones, added by barrels.

Their findings with regards to the purity of expression, levels of oxygen transferred to wines, and customer reaction to these wines, are partially supported by results from chemistry departments from the Hochschule Geisenheim University, Germany; the University of California, and the University of Florence, Italy (Easton, 2011; Miller,K.V.,Block, D.,Oberholster,A., 2019; Martellini, 2018).

What are the underlying theoretical ideas regarding alternative wine fermenters and ageing vessels? Why are winemakers, both locally and internationally, enamoured with concrete, terracotta, stone, and plastic? What are they using instead of the traditional stainless steel and new oak? How does this impact the wine drinker?

This dissertation explores the features of each type of alternatives as well as ovoid vessels in South Africa. In addition to the investigation into formal literature, interviews will collect data to provide possible benefits that are particular to alternative wine vessels in South Africa. Interview questions to support the research is not confined to the type of alternatives, if any, used by the specific winemaker, but also to how this winemaker interprets the technology and the specific benefits that the different wine vessels offer.

3. Introduction

Wine has been a part of humanity from the earliest times. History, in both text and imagery, often tells of wines in egg-shaped vessels. The Egyptians invented the amphora, but through travel, Europe was introduced to these vessels made of porous clay but lined with pine resin or beeswax to minimise leakage. According to the legend of Gilga, drinking fortifying 'poison' from an amphora and the Etruscans shipping wine to the Old World, all happened in clay.

Modern-day innovations have re-invented the spherical shape but enhanced it with stainless steel manways and airtight lids. Materials such as engineered concrete and food-grade plastic, are the new inclinations. Yet, there is a strong movement to use traditional vessels, such as amphorae made from terracotta and qvevri made from clay. Organic and biodynamic wine producers favour the terracotta vessels for the flavours they impart to wine, as well as the traceability of the material of production. An ever-increasing number of wine producers, both locally and internationally, are moving away from inoculating, and they are instead allowing natural fermentation to happen in the wines they produce. Alternative wine vessels, especially ovoid vessels, aid winemakers when using natural fermentation, as the shape of these wine eggs facilitates movement in the fermenting wine, which initially contributes to divine forces (Willcox, 2019), but that is now scientifically explained.

4. Concrete

4.1 Concrete ovoid wine tanks

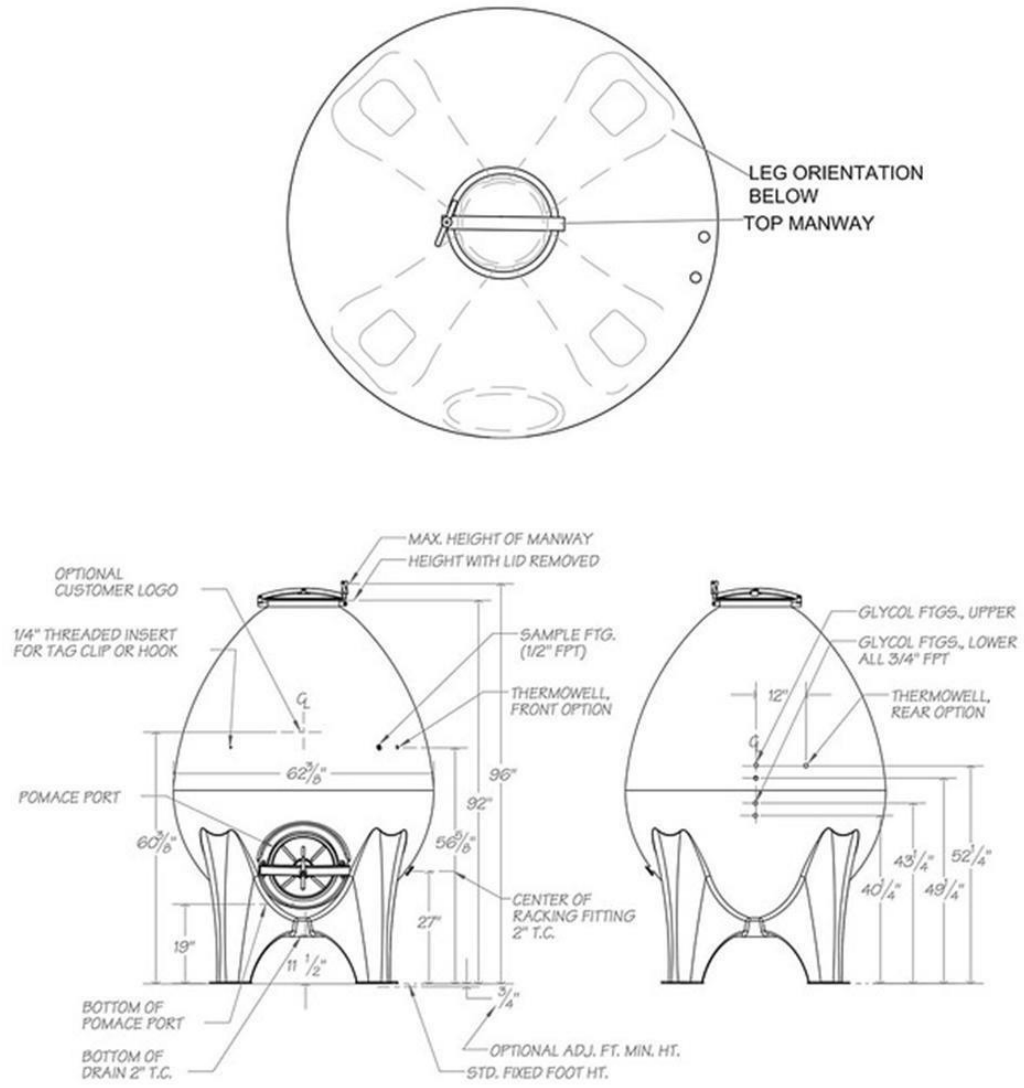

Figure 1: Diagram of cement ovoid wine vessel (IKapa, 2019)

Concrete eggs are essentially more significant and more modern versions of clay amphorae. They have a more porous surface than stainless steel, but less than clay amphorae, transferring minuscule quantities of oxygen over extended periods, but without the flavours imparted from oak fermentation. “It’s a purity thing. Cement does such a good job of showing a wine’s true terroir. Oak-even neutral oak-can mask those nuances and Stainless-Steel heightens the effect of acid in high-acid wines. Cement doesn’t do that. It doesn’t add or take away or masks the soil. It lets everything show.” (Barnard, 2019)

Concrete tanks offer high thermal inertia, controlled micro-oxidation, and are of course flavour-neutral and durable. In effect, they offer a combination of some of the best qualities of stainless steel

and wooden tanks. "Wines fermented in concrete display more weight, fruit intensity, texture and minerality than the same wines aged in stainless steel or plastic" (Winepress, 2017).
Most winemakers using concrete eggs, do not inoculate wines but allow spontaneous fermentation. Temperatures during natural fermentation are less aggressive, with a slower fermentation and lower fermentation temperatures than with an inoculated fermentation. Fast and high-temperature fermentation can affect concrete tanks, as it does not allow gradual heating of the concrete. Therefore it can cause cracks, especially where metal attachments and concrete join.

Interviews and articles, such as (Barnard, 2019; Elphick, 2019; Theron, 2017) showed that all wines produced in cement, are either produced by smaller producers, or as ultra-premium wines at larger producers. Cement egg standard volumes are between 550–1300 L, which is ideal for smaller producers, or for premium blends where components are fermented or matured in different vessels to contribute complexity to the wines. An example of this is Rupert & Rothschild Baroness Nadine Chardonnay of which a third is matured in cement, while the remaining components are matured in first and third fill oak barrels.

Winemakers comment that although most of these cement tanks have internal cooling, it is not needed, as the thickness of the walls, the ovoid shape and thermal inertia of the vessels, cause slower fermentation and therefore lower fermentation temperatures (Miller,K.V., Block, D., Oberholster, A., 2019). The unlined walls of the tank allow the heat that is generated during fermentation to dissipate more efficiently. The concrete walls act as an insulator, in comparison to thinner-walled vessels such as stainless steel, and the slow heat exchange and constant temperature inside the tank allow for slower fermentation and a slower extraction of tannins. According to Nadia Barnard, the winemaker at Waterkloof (Barnard, 2019), and Tim Elphick, winemaker at Portsea Estate, Australia (Elphick, 2019) the ovoid shape keeps the liquid in motion during fermentation. Both winemakers measured a difference of between 1–2°C between the bottom- and top-fermenting liquid.

The concept of divine forces at work, according to Chapoutier (Jarvis, 2019), has been researched and studies have explained the vortex formed during fermentation (Easton, 2011; Clayver, 2016). The heat, as well as movement generated by yeast molecules during fermentation, allows the liquid inside the egg to create a vertical and sideways vortex. The fermenting liquid moves upwards as heat is generated during fermentation, cooling down in the narrow conical neck of the vessel and sinking, only to push upwards again when reaching the bottom.

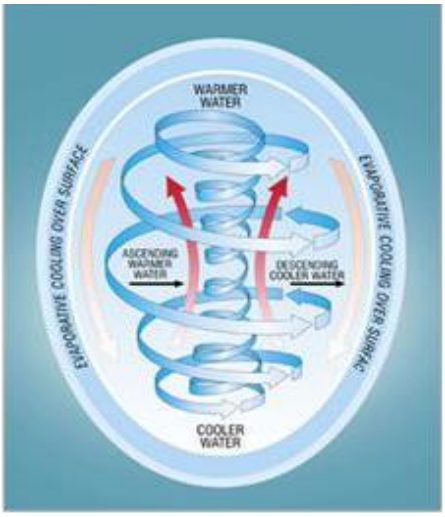

Figure 2: Torus vortex inside sphere-shaped fermenter (Calvert,

This constant movement, in no small extent, eliminates the need for pigeage and batonnage as the wine stays in contact with the lees much longer. Only in slightly less conical vessels, like the Tulipe shape tank, and in concept shapes like the Teacup, is it necessary to wet the cap at times during fermentation.

In the study, Predicting fermentation dynamics of concrete egg fermenters (Miller, K.V., Block, D., Oberholster, A., 2019) doubt is cast on the effectiveness of the vortex. It suggests that a cylindrical stainless-steel tank, with a cooling jacket, has better mixing properties. The hypothesis was not

proven, and no conclusive answer was reached. Studies on the fluid dynamics inside stainless steel versus a concrete egg are continuing at the University of California. Dr Maximilian Freund, Geisenheim Research Centre, has found that in terms of the shape of the wine eggs, there seems to be no difference between stainless steel and concrete, fermenters. The longer fermentation may account for more aromatics to be present in the wine. The completed study focused on Rheingau Riesling and is continuing concerning other white varieties (Easton, 2011). The lack of corners in the egg means there are no dead areas, and therefore there is uniformity within the wine. "The uniformity and slow pace of fermentation help to produce complex wines, with more concentrated flavours" (Jarvis, 2019).

Tony Bish, winemaker Sacred Hill Wines, Gisborne, New Zealand, believes that some yeast clings to the inside surface of the lower half of the egg, as well as being kept in suspension by the vortex (Jarvis, 2019). Concrete wine eggs are inert and interviewed South African winemakers (Barnard, 2019; Jordaan, 2019; Visser, 2019) agree with Bish that the internal surface of the tanks acts as a development zone for the yeast build up from year to year, emphasizing the terroir of each particular wine. Cement vessels are cleaned with soap and lukewarm water solution after use, allowing penetrated yeast residue to add layers of flavours in subsequent years. One of the negatives regarding the cement egg is that the unlined concrete needs protection against corrosion. In wines with high acidity, such as Riesling and Sauvignon Blanc, it takes special care to prepare the tanks. Tartaric acid washes after usage eventually form a 'skin' on the inside of the tank, protecting the unlined inner against corrosion.

Well-made wines have complex layers of expression. Fruit notes should complement other flavours, such as the oxidative flavours added through ageing. Traditionally, wood lactones would have been part of these non-fruit flavours. However, more and more winemakers, specifically in the New World, are opting to expose wines to micro-oxygenation through non-wood, such as wine eggs. Tim Elphick (Elphick, 2019) agrees with Justin van Wyk, Constantia Glen, (VanWyk, 2019) that wine should be a true expression of site, and not influenced or manipulated through the use of new oak. "Cement eggs, through slow oxygen exposure, and being a neutral flavour vessel, allow for wines to express actual variances attributed to vintage" (Elphick, 2019). Werner Michlits, Meinklang Winery, Burgenland, Austria, compared the same wine in oak, stainless steel, and concrete, and concluded, "that concrete had the best texture and mouthfeel; it was fuller, rounder, and with more complex darker fruit on the Sankt Laurent. Wood gave more tannin structure; stainless steel was the lightest" (Meisner, 2016). Research at the University of California shows that there is no difference in pH and TA in wines fermented in concrete, in comparison to those fermented in stainless steel or wooden barrels. Flavour differences in wines are contributed to the slow rate of micro-oxygenation, the slow pace of fermentation, and the continued suspension on the must during and after fermentation (Miller, K.V., Block, D., Oberholster, A., 2019). Concrete, like oak barrels, is slightly porous, which assists in oxygenation. However, oxygen does not only come from outside. The primary source of oxygen inside a concrete wine tank is released from tiny bubbles and pockets on the interior, which forms as the concrete cures during the manufacturing process (IKapa, 2019). This micro-oxygenation helps yeasts thrive, which is especially beneficial to winemakers, only allowing natural fermentation for the wines produced in these vessels.

Colour in red wines made in egg-shaped vessels are generally more profound than red wine fermented in a stainless-steel tank or wooden barrels, due to the narrow top of the ovum shape. The majority of the cap is continuously immersed in must, causing constant colour extracting and no need for batonnage or pigeage. The shape of the egg assists with the softening of tannins during the maturation of red wine, due to more substantial surface contact with lees (Calvert, 2017).

The microporosity of the concrete means there is no valid reduction in liquid levels, so no need for top op during the fermentation or maturation period. Reduction in liquid levels directly translates to a loss

of income, with even a 1% loss in traditional oak barrels or even open stainless-steel fermenters representing a substantial amount for most wineries.

Figure 3 support this finding specific to wooden barrels. Wine in barrels has up to a 10% loss of volume per year, if not stored in a humidified, air-conditioned environment. This loss can amount to as much as 6 bottles of wine per year per barrel (Blazer, 1991).

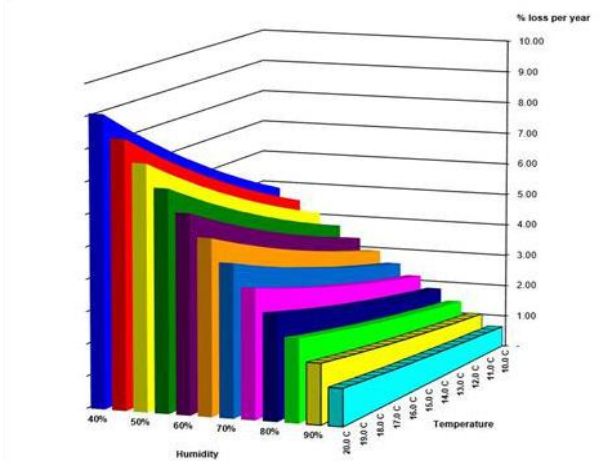

Figure 3: Estimation of evaporation from wooden barrels (Block, D.E.,Miller,K.V.,Oberholster, A., 2019)

Choosing concrete, adds the oxidative component, without wood lactones – the concrete egg provides another tool to get to the winemaker's stylistic goal. Reductive wines are fermented in stainless steel, as stainless-steel does not allow any oxygen transfer to the wine. After being in stainless steel, the fruit is brighter, offering polished flavours, a more pronounced flavour profile than what is naturally expressed by the wine. Good winemaking is mindful of producing wines not representing single fruit notes, but rather complex layers of primary and secondary flavours. Non-stainless-steel wine vessels contribute to the development of secondary flavours, without masking or changing primary fruit flavours. Winemakers and researchers (Del Alamo-Sanze, M., Martinez-Gil, A.M., Nevares, I., Sanchez-Gomez, R., 2018) concur that wines fermented in concrete have a textural quality which cannot be replicated by other wine fermenters. The role of oxygen in winemaking and ageing is softening harsh tannins and astringency, achieved through polymerising short-chain molecules into longer ones, resulting in creamier mouthfeel and velvety texture.

Winemakers (Williams, 2019; De Waal, 2019) concur that concrete egg tanks are best suited for wines whose style excludes contact with oak, and for varieties that would benefit from micro-oxygenation. Research completed by The Australian Wine Research Institute (AWRI), measured the oxygen transfer rate in concrete tanks at about 4mg/L/month, with no lactones or flavours added other than oxidative flavours, which contribute to mouthfeel and texture (Calvert, 2017). In comparison, wine in wooden barrels receives an average of around 20mg/L/year, which decreases with the age of the barrel (Kelly, M., Wollan., 2003). This oxygen transfer rate is influenced by the specific type of oak used, grain of wood as well as type of bung used (Du Toit, 2016). Oxygen uptake in denser vessels, such as cement and high-density amphora have a smoother and stable oxygen uptake over a year; in comparison to wood, where around 50% of the annual oxygen update happens during the first quarter of the year (Passin, 2019).

South African winemakers use concrete eggs for fermentation and maturation, in both white and red varieties. White varieties predominantly used, in line with both New and Old-World producers, are Chenin Blanc, Chardonnay, and Semillon to a small extent.

Examples include:

- Rupert and Rothschild Baroness Nadine Chardonnay: About 30% ferments in cement, while the other components age in traditional 300 L barrels.
- Sadie Family Wines Palladius: Fermented per cultivar component in Nomblot eggs and left for a minimum of 11 months in either Nomblot or clay amphorae.
- Waterkloof Seriously Cool Chenin Blanc: Where the juice after settling for 12 hours, is racked into concrete eggs as well as older 600 L barrels for fermentation.

Red varieties are not yet as extensively fermented and aged in cement. Red varieties used are mostly Grenache, Shiraz and Cinsault. Grenache and Cinsaut, as per Duncan Savage, Savage Wines (Savage, 2019) and Paul Jordaan, Sadie Family Wines (Jordaan, 2019), benefit from more reductive winemaking practices, and less wood treatment. The cement tanks used for these red varieties are usually epoxy-coated on the inside to minimize micro-oxygenation, such as the Nico Velo iron epoxy painted tanks used by Sadie Family Wines for Grenache and Cinsault. Shiraz, when done in alternative wine vessels, is mostly fermented in unlined cement or the more oxidative amphorae or qvevri, as with Savage Wines Syrah and Avondale Qvevri Grenache, Syrah & Mourvèdre red blend.

The mass of concrete is a benefit, but it also has a negative aspect. The concrete eggs are extremely heavy. Wineries should plan the placing of concrete eggs, since moving the vessels requires specialized equipment. Standard forklifts do not have the lifting ability – not even for smaller size concrete eggs. Wineries must consider sunlight as a factor when placing eggs, due to the thermal conductivity of cement. Conclusions from interviews with winemakers concur that the mass and thickness of walls of the cement eggs aids in slow changes in temperature during fermentation. According to winemakers interviewed and winemaking literature, slow fermentation is an essential requirement for good winemaking.

"Most winemakers agree that a slow fermentation is better. The thinking goes that wine holds on to more varietal characteristics as well as delicate flavours and aromas created during fermentation. More aggressive fermentations tend to blow all varietal character out the airlock, so to speak" (Hayes, 2015). Slow fermentation at lower temperatures aid in higher levels of fruit esters developing, confirming why wines fermented in cement, show the purity of fruit without the need for additional cooling. The purity of fruit flavours was continuously mentioned by interviewed winemakers (Barnard, 2019; Elphick, 2019) and is substantiated by articles (Calvert, 2017) and studies (Del Alamo-Sanze, M., Martinez-Gil, A.M., Nevares, I., Sanchez-Gomez, R., 2018) quoted. All concur that the slow fermentation and constant temperature inside the eggs allow the varietal aroma and flavour compounds to develop. Winemakers commented on the difference between wines fermented and matured in concrete, versus those in stainless steel, citing brighter and more polished flavours. Although winemakers mention minerality, most winemakers do not attribute this solely to concrete, but rather to a better expression of terroir, due to the neutral nature of the concrete vessels. Many winemakers find that concrete preserves fruit flavours and aromas, unlike oak which imparts vanilla, tannin, and spice notes.

Natasha Williams, winemaker Bosman-Adama wines, mentioned crisper and brightness flavours and better expression of varietal character (Williams, 2019). Cement heats slowly but retains heat. "As heat is released during fermentation, it was trapped in the fermenter because of weak heat exchange with the environment, warming the fermenter. This increase in temperature, in turn, increased the yeast metabolic rate, which further increased the heat generation rate, resulting in an increased temperature and fermentation rate feedback loop. These fermentations had a peak heat generation rate of 225–250 watts. In comparison, the heat was much more readily exchanged to the ambient air in the forced convection simulations, which yielded a peak heat generation rate of 150 watts, resulting in a much cooler, slower fermentation" (Miller,K.V., Block, D., Oberholster, A., 2019). Figure 4 shows how the thickness of the walls of the cement tank is slow to heat up during fermentation, even with high outside temperatures. The slower fermentation can be attributed to the vessel and the ability thereof to absorb heat slower than other materials. Also note that the majority of wines made in cement vessels are not inoculated but fermented by natural yeast which ferments at a slower rate, which in return also assist with the development of flavour. Concrete is an excellent insulator against temperature fluctuations during fermentation, because of the thermal inertia the material offers.

In contrast, stainless steel is conductive and transfers external temperatures to the wine inside. Stainless steel, without the help of cooling jackets, also heats up quickly during temperature rises during fermentation. Maintaining temperature is crucial during fermentation, and concrete offers excellent insulation against temperature changes.

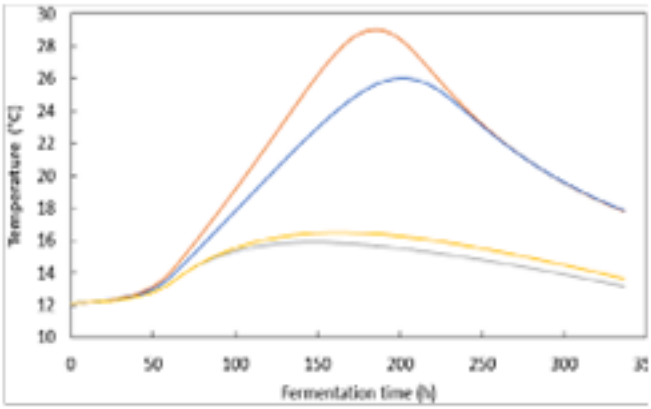

Figure 4: Temperature inside and outside cement tank during fermentation. Note the slow and low increase in temperature inside the vessel versus the spike in outside temperature (Miller, K.V., Block. D., Oberholster, A., 2019)

A significant concern is that concrete eggs need to be cleaned carefully before and after use. Any concrete egg is prepared before use by washing with12% tartaric acid aqueous solutions. Hot water is not advisable, especially if there are any metal parts built into or attached to the tanks. Nadia Barnard, winemaker Waterkloof had the unfortunate experience of filling a cement egg with hot water and 'cracking an egg'. The vessel can crack if too high a temperature difference occurs between metal and concrete. Again, the thermal conductivity must be considered.

Temperatures between 30 – 32°C are ideal for cleaning. Aggressive cleaning measures, such as hard-bristled brushes, cannot be used. Hard bristled brushes can cause scratches on the internal surface, creating areas for fungal growth. Alkaline cleaners such as peroxyl carbonate-based products are best for optimum cleaning. High-pressure cleaning with lukewarm water followed by a tartaric rinse and a final lukewarm water rinse is the norm for South African winemakers using concrete eggs.

The properties of egg fermenters mean that the winemaker requires less intervention, due to slower fermentation, no need for batonnage or pigeage, inability to move vessels, and ease of cleaning. This labour reduction can be very appealing for smaller producers and offset units and freight costs to some degree. Concrete eggs are substantially more expensive than stainless steel and wooden barrels. The cost is attributed not only to the cost of manufacturing but also to the cost of transport. The cost of a Nomblot 6 hl wine egg is about R50 000, excluding international transport. Other international manufacturers, such as Nico Velo and Sonoma Stone, sell in a similar price range. The advantage is that the concrete tanks last longer than wooden barrels, so the cost per use eventually is more economical. The decision between stainless steel, wood, and concrete comes down to the style the winemaker wants to produce.

4.1.1 IKapa Concrete eggs in South Africa

IKapa started its sojourn into the South African wine industry with square wine tanks, which has the advantage of maximizing cellar space. Boschendal, Bellingham and Noble Hill are amongst those using IKapa square tanks. Square tanks are predominantly used in red winemaking, due to the large open top. Consequently, they produce wines with more oxidative flavours, specific to the red wine spectrum. Oak staves, chips or other alternative wood regimes are traditionally used in square tanks to add traditional flavours associated with barrels. Square tanks are still used extensively in Old World areas, such as Burgundy. In South Africa, old square cement tanks are converted into small tasting

rooms, such as at Klein Roosboom, or they are used only during red wine fermentation for easy punch-down.

IKapa produced the first IKapa Eon wine egg in 2017. The ovum-shaped concrete tanks are produced in the Western Cape, South Africa from Portland cement, washed granite stone, washed dune sand, chlorine-free water, and no added chemicals. The polypropylene micro- fibres meshed into the structure, reinforce the vessels and make the tanks slightly lighter than other concrete wine tanks, at around 1950 kg for a 1520 L tank. IKapa tanks are unlined, and thus slightly porous. The unlined tanks, together with the thickness of the walls, between 80–120 mm, allow for slow micro-oxygenation to take place.

IKapa Eon ovoid wine tanks are used extensively in the South African wine industry by winemakers, Rudi von Walzleben from D'Aria, Nadia Barnard from Waterkloof, Duncan Savage from Savage Wines, and Ricus Neethling from Bizoe wines. They comment as follows: (IKapa, 2019)

“Assists in oxygenation of the wines.”

“Thermodynamics of the shape aids fluid movement for temperature and reduces pressure on the lees.”

“Shape also aids the deposition of the lees across a larger floor area than a barrel and avoids the need for stirring.”

“The thermal dynamics of cement is unsurpassed, the egg shape playing a huge role in thermal currents within the tank allowing the lees to remain in contact longer.”

When asked why they chose IKapa, the lower cost in comparison to imported concrete ova is a factor, but as noted by Duncan Savage, Savage Wines, who also uses locally produced amphorae: "Anything as long as it is local" (Savage, 2019).

IKapa also produces 40L cement eggs, mostly used by winemakers for experimental wines. Nadia Barnard, the winemaker at Waterkloof, is currently experimenting with carbonic maceration of Grenache in a 40L IKapa ovum.

Figure 5: IKapa 40 L Mini Eon Wine Egg at Waterkloof Wines, used for experimental wine, currently Grenache. (Photo credit Wanda Cronje)

4.1.2 Nomblot

Nomblot was founded in 1922, in Burgundy, France, by Etienne Nomblot and is regarded as the world leader in the manufacturing of modern, concrete wine eggs. Initially, they only manufactured tanks in the traditional square Burgundian shape, but since the 1980s they are also manufactured in a round and conical egg, as well as in amphora shapes. Egg-shaped Nomblot eggs came about, due to a request from Michel Chapoutier to Etienne Nomblot in 2001. Ancient amphorae, the Georgian Qvevri, and the traditional barrel shape were the inspiration to Chapoutier that the egg is an ideal form of a container for fermentation and the ageing of wine. Chapoutier strongly believed that the oval form efficiently

harnesses physical and cosmic energies, resulting in a product that is in balance with the physical and spiritual environment.

The Nomblot eggs are available in 710 L, and 1730 L. The larger Nomblot tanks are cone-shaped on the outside, but with ovoid inners. Winemakers in South Africa who use Nomblot, include Eben Sadie from Sadie Family Wines, Swartland, Natasha Williams from Bosman Adama Wines, Wellington, and Justin Van Wyk from Constantia Glen, Constantia Valley. Although from areas with different terroir and with varying techniques of winemaking, these winemakers are all in agreement that the Nomblot eggs contribute to the end quality of the wines. Eben Sadie was the first to use Nomblot in South Africa when he bought his first Nomblot eggs in 2004. He comments that the tanks "adds more depth and structure to the wine, but do not let wines go flabby; they stay linear, dense and tight. It is finer stitching " (Sadie, 2017). Justin van Wyk uses Nomblot for Semillon blended into Constantia Glen Two. He remarks that "the egg acts very much like oak barrels in creating texture but without imparting any wood spice. They preserve fruit flavours, and aromas like stainless do" (VanWyk, 2019). Natasha Williams uses Nomblot for Chenin Blanc and "is happy with the depth the wines fermented in the concrete shows" (Williams, 2019).

Figure 6: Nomblot Eggs at Sadie Family Wines. (Photo credit Wanda Cronie)

4.1.3 Nico Velo concrete

Nico Velo is an Italian concrete wine tank producer, in South Africa, used primarily by Sadie Family Wines. The first concrete wine tank brand to incorporate cooling into the walls of the tanks, all tanks now feature the 'serpentine coil,' a heating or cooling system built into the walls of the tanks. "Managed by a thermal sensor; performance is optimized based on the inertia and the relative mass of concrete, to keep the temperature constant and uniform over the entire surface" (NicoVelo, n.d.).

The original concrete tank produced by Nico Velo was the Flacon specially designed for use in white wine production. The convex shape assists in the continuous suspension of the lees, creating creamier

mouthfeel. Due to the small size, only 600 L, it is ideally suited for small producers or experimental wines. All concrete tanks produced by Nico Velo, also feature integrated coils for temperature management in the walls and bottom.

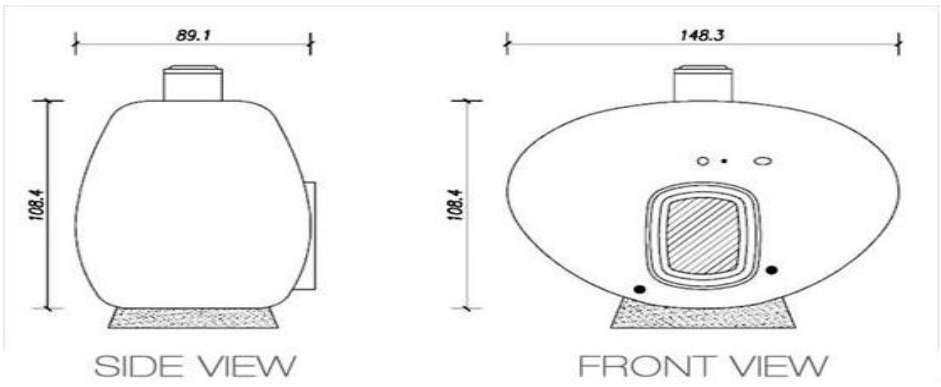

Figure 7: Flacon wine vessel as produced by Nico Velo tanks (NicoVelo, n.d.)

Sadie Family Wines do not use the Flacon, but the Nico Velo Tulipe concrete tanks. The tanks feature a truncated, oval shape on the outside, but with an ovoid inner. The tanks are all used for red wine fermentation for the Ouwingerd series. All but one of the tanks are unlined to facilitate micro-oxygenation. As with other ovoid concrete tanks, a vortex, due to the heat generated during fermentation, moves the must and enables an equal, and slow fermentation. Eben Sadie believes that Grenache for Soldaat does not benefit from micro-oxygenation and makes the wine in a reductive style. The Grenache ferment and mature in Nico Velo tanks lined with an ironed epoxy paint to minimize any oxygen transfer. After a year in cement, the wine is transferred to old Foudres for maturation. The lined format of the tank for Grenache allows Sadie wines, after pressing of the cap, to leave the wine in the concrete tanks for another 11 months, still resulting in a reductive style Grenache. The cup shape of the truncated tank together with the lined inner, enables the Tulipe to act as both fermentation and maturation vessel for reductive wine styles. Fermentation for these red wines usually takes up to a month, due to the low internal temperatures of the tanks. Paul Jordaan, cellarmaster at Sadie family Wines commented that "although all the concrete Nico Velo tanks come equipped with serpentine cooling built into the walls, it has never been necessary to use, due to the thermal inertia of the concrete. The temperature during fermentation in the Nico Velo tanks is usually around 22°C, giving us the concentration, we want" (Jordaan, 2019).

Other wine tank shapes produced by Nico Velo tanks, but not yet used in South Africa include:

- Iside: A 600 L tank designed explicitly for biodynamic wine producers. The upside-down triangle shape is according to the rule of the golden number as used by the Egyptians who constructed the pyramids.
- Quadrangular barrels: Similar in shape to IKapa square tanks and Sonoma Nubarrels, these vessels optimize usage of space in a cellar. It does not offer the natural movement created by the heat vortex in ovoid vessels, and batonnage is completed manually.

Figure 8: Iside wine vessel (NicoVelo, n.d.)

- Truncated pyramid tanks and barrels: These concrete tanks offer winemakers different options for fermentation, due to a lesser ovoid inner. As with other tanks produced by Nico Velo, these tanks have the serpentine coil, copyrighted by Nico Velo, built into the walls of the tanks.

4.1.4 Sonoma Cast Stone

Don Van Staaveren, the winemaker at Three Sticks Wines, Sonoma Country, USA, mentioned the idea of concrete tanks to his neighbour Steve Rosenblatt, the president of Sonoma Cast Stone in 2001: "In the early history of winemaking, concrete tanks were very prevalent, and there were some outstanding wines made in concrete tanks," Van Staaveren said. "So, I thought, well, there is no reason why we cannot do it again (Bussewitz, 2012).

4.1.4.1 Sonoma Stone Wine Eggs

The first concrete egg sold by Sonoma Cast Stone was in 2011, and although the company experienced a decline in sales over the last five years, they are still selling concrete tanks, primarily to the US market. Sonoma concrete eggs, when compared to Nomblot and IKapa, are narrower at the top and bottom of the egg, which causes a vortex to be present even after fermentation. Several wineries in the USA, for example, Thomas George Estates, Sterling Vineyards, and Cliff Eede Vineyards use Sonoma specifically for fermenting Chardonnay, which is left in the tank on the lees for maturation.

Sonoma concrete eggs, like other concrete egg manufacturers, also have internal cooling built into the walls of the tank. Sonoma Stone uses glycol in the tubing, in contrast with other manufacturers who offer the option of water or glycol. The most significant contrast between Sonoma stone and other concrete wine tank manufacturers is the weight of the tanks. The inside casting is colourless concrete made with chlorine-free water. The thin outer layer is composed of EarthCrete™, a trademarked FiberCast concrete that is environmentally sustainable, stronger, and lighter than traditional concrete. EarthCrete™ contains recycled concrete, porcelain, and glass. This combination gives maximum strength and facilitates the more effortless movement of the tanks. As EarthCrete™ uses reclaimed material, it benefits the factory as it re-uses excess materials.

According to Steve Rosenblatt, the microporosity of the tanks causes natural micro-oxygenation of the wine, and the specific stone used for the tanks add some minerality to the wines made in Sonoma Cast Stone wine eggs. "The wine loves to touch the concrete for two reasons. One is the air exchange; the other is it picks up a minerality" (Bussewitz, 2012).

Winemakers who use Sonoma concrete eggs concur that the wines made in these vessels have a textural quality that cannot be duplicated in stainless steel or wooden barrels. Aromatic flavour concentration, great mouthfeel, and good minerality are descriptors for wines fermented and matured in Sonoma Stone wine eggs.

4.1.4.2 Nubarrel by Sonoma stone

Nubarrel is a square concrete vessel that offers the benefits of both concrete and oak. The most significant advantage is that the vessels are stackable, which results in additional floor space in cellars where space is limited. Nubarrel is a customizable wine fermentation and maturation vessel. It offers benefits such as temperature control and a choice of oaking regime. In contrast to egg-shaped vessels, the corners inside the Nubarrel create areas of slower and faster fermentation. It comes equipped with glycol-filled heating coils, that regulate temperature during fermentation and maturation.

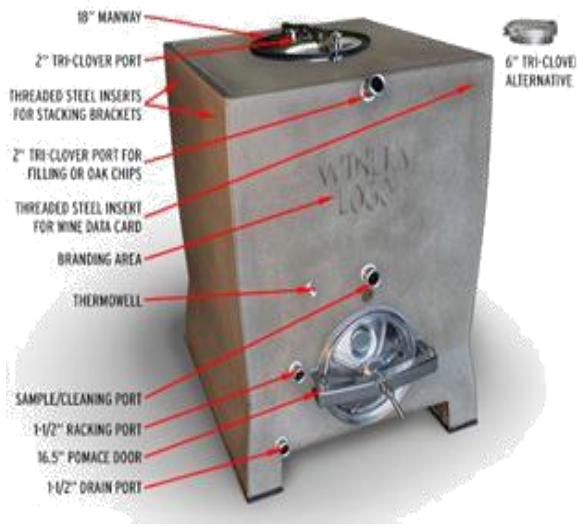

Figure 9: Nubarrel by Sonoma Wine tank with all descriptors (SonomaWinetanks, n.d.)

The winemaker can decide between using oak staves or chips. A choice of an oak stave holder or oak sleeve for chips can be added. The immersion rack for the staves or chips can be removed or altered during the fermentation period, which creates opportunities for winemakers to decrease or increase wood contact during the maturation period.

As with all unlined concrete wine tanks, minuscule quantities of oxygen impart to the wine through the porosity of the concrete. Winemakers who want to expose specific wines to specific levels of oxygen contact during fermentation and maturation can control micro-oxygenation levels by using the sparging stone, with which the vessel is equipped. Traditionally, the bung on a barrel is removed for daily sampling, allowing oxygen into the barrels. In contrast, Nubarrel has an airtight flavour port, which enables the winemaker to do daily sampling without exposing the wine to oxygen, aiding in ease of control of oxygen uptake. The control of micro-oxygenation and wood regime can be pre-planned by winemakers, which is especially beneficial in a massive cellar operation where the winemaker must delegate to non-qualified personnel.

Winemaking appellations in the USA, as in South Africa, are traditionally not in high rainfall areas, and with water scarcity being an international reality, Sonoma Stone claims that a Nubarrel requires a third of the water needed to clean a traditional wooden barrel (SonomaWinetanks, n.d.).

Labour saving counts as another cost factor as the Nubarrel can be filled and cleaned, without moving it. Lower labour cost and water savings are significant factors to consider when choosing a fermentation vessel. Although Nubarrel is not used extensively in South Africa, Orange River Cellars did experiment with Nubarrel in comparison with plastic Flexcube maturation vessels. There was no conclusion as to which is the better solution. Flexcube, as discussed, is significantly cheaper than Nubarrel, and weighs less, which contributes to a lower initial cost.

4.1.4.3 Other Sonoma Stone wine tanks:

- Conical: The conical tanks are available as open-top or closed with large manways. The tanks come in sizes, 830-, 950-, 1010- and 1070- gallon; one gallon being 3,78 L. The large pomace port makes the conical tanks ideal as both white and red wine fermenters. As with all Sonoma Cast Stone tanks, the tanks are available in a variety of colours and can be placed on a raised foundation, powder-coated steel adjustable ring support, or matching concrete legs.
- Tower: The height of the tower tanks and that they can be lined up flush against other aids enables maximum cellar and storage space. The tanks can be equipped with a closed or open top, depending on the specific requirements of the client. Sonoma is the only company that tailor tanks to the specific needs of a client with regards to embedded lights. Due to the height of these tanks, they can be fixed onto the floor or on a steel base.

- Square: The square tank makes the most efficient use of limited winery floor space of all the tanks produced by Sonoma Cast Stone. For cohesiveness, tank fittings can adjust to mirror the adjacent tank. These tanks are available with and without tops.
- Segment tanks: The segment tanks are a modular system manufactured to the exact requirements of the client. As the configuration is specific, this system is well-suited to large wineries with constraints in terms of space and dead areas.
- Teacup: The 274-gallon tank resembles half an egg. It is an open-top fermenter and is ideal for a small winery or a one working with small or experimental batches. Due to the wide open-top, it is easy to monitor fermentation and do punch-downs. The two lifting rings on the tanks allow the tanks to be lifted in such a way to facilitate pouring.

Figure 10: Teacup wine vessels. ideal for use as open fermenters for small batch winemaking. (SonomaWinetanks, n.d.)

4.2 Conclusion on Wines in concrete

Interviews and literature are not conclusive that concrete is a better medium in which to ferment and mature wine. As yet, there is no reliable evidence that puts the cement egg as a better medium for winemaking. The characteristics that do define the use of the concrete egg are, that primarily it gives the winemaker another tool to create a specific style of wine. Winemakers have some idea of what they want to achieve as a final product, and they use the characteristics of the concrete to assist them in their goal.

It is, however, a medium that gets everyone that encounters them excited – winemakers and visitors to cellars alike. The tactility of the vessels and the strange bulbous shape draw people to them. As a focal point in a cellar, it draws attention. It brings some prestige to a cellar for being 'hipster,' (Gerber, 2019) as per Boela Gerber, winemaker at Groot Constantia, as well as 'up to date' (DeWaal, 2019) with new methods of winemaking.

5. Ceramic Clay

"Ceramic usually refers to the finished product of clay after being fired to a high temperature, while terra cotta or earthenware is generally low fired." (Nautiyal, 2017)

5.1 Clayver

Figure 11: Clayver vessels, flat tops for ease of cleaning. (Clayver, 2016)

The selection of ceramic wine fermenters in South Africa is currently limited to Clayver. The small size, 400 L, makes it useful for experimental or small batch wine production, experimental batches, or for fermenting a small component for a specific wine.

“Clayver is a ceramic ‘Egg Shape’ Wine Fermenter container explicitly designed for winemaking, including fermentation, conservation, and ageing’’ (Clayver, 2016). Like the concrete and clay wine vessels, Clayver is manufactured from sandstone, a natural product. It originated in the Abilsolla district in Italy, a non-wine area, traditionally associated with art and pottery. Terracotta, also a pottery medium, sparked the interest to develop an ovoid wine vessel from a harder clay-like material. Clayver is a highly engineered wine vessel; the sandstone is compacted to such a degree that it resembles the density of granite. The sandstone is free of any iron residue, due to the extremely high temperature the vessel is fired. Terracotta and clay soils generally have high levels of iron residues, which does not burn off during firing. The high temperature during firing, and the density caused by compacting the sandstone during manufacturing, results in no need for linings to prevent evaporation of liquid.

In the official Clayver brochure, Clayver is compared to concrete, terracotta, and stainless steel. Allowing micro-oxygenation between the outside and inside of the vessel, as well as low thermal inertia, seems to be the two essential similarities between Clayver and the other vessels manufactured from natural materials. Although the material is regarded as micro-porous, allowing small quantities of oxygen to come into contact with the wine, winemaker Justin van Wyk, Constantia Glen, disagrees. Justin uses Nomblot, amphorae, and Clayver. He regards Clayver as "a beautiful vessel, ideally to store wine, but not for maturation, except if wanting to keep it in there for a very long time" (VanWyk, 2019). If comparing the thermal qualities of Clayver to concrete specifically, Clayver offers better

insulation, due to the higher temperature at which the vessels are fired, in comparison with cement which cures at ambient temperatures. The high temperature the vessel is fired at, makes it neutral in flavour, unlike terracotta amphorae that contribute some flavour to the wines.

Similar to other ovoid wine vessels, Clayver is sphere-shaped. If using for maceration, the shape is ideal for keeping the must in contact with the skins, which is an excellent benefit for colour and flavour extraction. For ageing, Clayver claims that the thickness and dense structure of the walls offer optimal high thermal inertia and allow one-tenth of the oxygen transmission of barrels (Goode, 2013) supporting the comment by Justin van Wyk as to the permeability of these vessels. The Clayver fermenter has a flat top made from tempered glass, which therefore illustrates excellently the vertical current created by yeast fermentation present in all ovoid spheres.

5.2 Vital vessels

Figure 12: Magnum 675 ceramic vessel (VitalVessels, 2014)

Vital Vessels, California, USA recently purchased the rights to manufacture Magnum 675, a slip cast ceramic wine fermenter designed by Phillip Sedgman, Murray River, Australia. The Magnum 675 is the commercial version of the Magnum 43, both named after the quantity it holds. The Magnum vessels were initially manufactured in Australia, specifically for use in biodynamic winemaking and the ovoid shape cast as a slip cast ceramic.

The ovoid shape, as with other vessels discussed, creates a torus vortex, vertical and sideways, during fermentation. Ceramic, due to high firing temperatures, creates a neutral vessel, with low porosity. The cross-cut in figure 12 shows the thin walls of the Magnum wine fermenters, 11–12 mm, yet the pace of micro-oxygenation is similar to concrete wine fermenters (Elphick, 2019), which has thicker walls of 80–120 mm. Ceramic eggs are more fragile than concrete but light enough for a forklift to

move around or for drainage of pomace. The lighter weight impacts directly on freight cost, making them more cost-effective than concrete. The thin walls eliminate the need for internal cooling as evaporative cooling lowers the surface temperature, causing the torus vortex to occur.

Biodynamic winemakers use Magnum Wine eggs as the clay is fired at extremely high temperatures, destroying all chemical residue in the material. As with Clayver ceramic vessels, Magnum wine eggs are unlined and does not necessitate any pre-treatment to counter possible leakage. Lids on the vessels are cork, which aids in oxygen transfer, but can be sealed with beeswax to limit exposure to oxygen during maturation.

Biodynamic winemakers specifically are hesitant about using concrete, due to chemicals used during the manufacture. Concrete wine fermenters are generally not made from organically certified soil, and chemicals leech into the soil through non-organic farming practices. Concrete is cured, not fired, resulting in possible chemical residues present in the material.

Natural fermentation is a long and slow fermentation. Winemaker Tim Elphick, Portsea Estate, Australia, (Elphick, 2019) claim that the Magnum 675 when used in fermentation, helps with a more even ferment due to minimal temperature differences between the top and bottom of the internal vessel. Tim Elphick measured a degree difference between top and bottom during fermentation. Micheal Sexton, winemaker Main and Cherry, Australia, uses the Magnum 765 for the maturation of red varietals, specifically Sangiovese. His findings are that the ceramic vessels offer a slower oxygen transfer than oak, but that the tannin structure of the wine matured in ceramic in comparison to oak, is less harsh in ceramic (Sedgman, 2017).

Magnum Wine Eggs are not yet available in South Africa.

6. Terracotta clay

Terracotta is one of the oldest materials used for manufacturing vessels for the fermentation, maturation, storing and transporting of wine. The thermal insulation capacity of terracotta is what links it naturally to winemaking. To differentiate between terracotta and other clay, and recognize the value in oxidative winemaking, the definition is essential; "Terracotta is a type of clay that is typically reddish-brown in colour and fires to a lower temperature than most other clays. It is also called earthenware or low fire clay. If it is not glazed, it is porous after firing and absorbs water" (Hall, 2018). These pots link to the past but are becoming an artifice for the future of responsible winemaking. Beyond the romanticism involved in reapplying ancient techniques, terracotta pots offer unique exchangeable properties with wine. Terracotta is known to lessen acidity, allow micro-oxygenation and provide superior insulation, which is different from the characteristics of stainless steel, wood barrels, or concrete. There are several types of terracotta vessels available today, including the amphora, qvevri, tinaja, and the dolium. The ancient Greeks called them Pithos, the Romans Dolium, in Spain, they are known as Tinajas, and in Georgia as Qvevri.

6.1 Amphorae

"Wines from amphorae have more soul, but making them is a big challenge. If this challenge is mastered, however, it results in wines that are unforgettable and which are in a category of their very own: Wines that are characterised by tannin, with no pure yeast cultures or enzymes, filtration or sulphur, with a thick polyphenol structure, an orange colour and hints of spices, fine herbs, dry fruits and almonds" (Barisashvili, 2012).

Terracotta amphorae are used extensively in the South African Wine Industry. A move away from stainless steel and new oak to amphorae are driven by winemakers wanting oxidative qualities in wine, without the sterility of stainless steel or the additional lactones added by wood. Terracotta amphorae offer unique properties for wines, which are different from those in stainless steel, wood barrels, or concrete. The clay increases pH allows a consistent and slow oxygen exchange and provide insulation. The slow oxygen transfer at different temperature is what winemakers use to manipulate wines and allows for the development of wines with mouthfeel and textural qualities not able to be done with stainless steel or oak. Hamilton Russel, Hemel-en-Aarde Valley, was the first to use amphorae in South Africa, in 2005. The initial terracotta amphorae used were found to be too oxidative for the specific style of wine the winemaker had in mind. Yogi De Beer, a South African potter, sourced a denser clay from Hout Bay, also lining these amphorae with clay from the Hamilton Russel property, before firing. Comments made by Anthony Hamilton-Russel in 2005 resound when interviewing local winemakers using amphorae in 2019: "not so much a taste thing as a structural thing," and "enable the wine to develop without vanillans and tannins" (Stone, 2012).

Winemakers Paul Jordaan from Sadie Family Wines, Duncan Savage from Savage Wines, and Justin Van Wyk from Constantia Glen, (Jordaan, 2019; Savage, 2019; VanWyk, 2019) all agree that amphorae breathe, adding complexity, texture, and mouthfeel to wines fermented and matured in these vessels. Unlike oak, terracotta amphorae do not impart any flavour but highlight the fruit aromatics of the variety. Many of the winemakers using terracotta amphorae do not inoculate their wines but allow natural fermentation. As with concrete, terracotta has thermal inertia well-suited to slower fermentation, which is a characteristic of natural fermentation.

The winemakers using natural fermentation comment that when using terracotta amphorae as fermenters, less sulphur dioxide is needed as a preservative, due to terracotta being an inorganic medium which does not harbour microbial spoilage organisms.

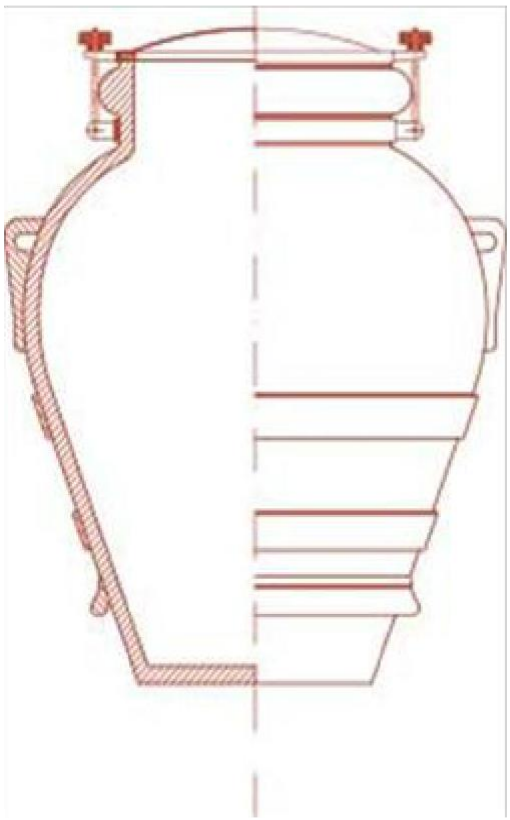

Figure 13: Crosscut of Cotto Manetti Amphora (Winemachinerygroup.com)

400 L
H 108 cm
Diameter 102 cm
Weight 200kg

500 L
H 112 cm
Diameter 108 cm
Weight 260 kg

600 L
H 118 cm
Diameter 115 cm
Weight 300 kg

Measures are approximate as amphora is handcrafted

- Average thickness of Terracotta: 3 cm
- Inox steel latch diameter: 53cm
- Drain hole: 4,5 cm

The present principal International suppliers of amphorae to the South African Wine Industry is Artenova, Italy; Cotto Manetti, Italy; TAVA, Italy, and locally potter, Yogi de Beer. All the above manufacture amphorae in the traditional way, building them layer by layer by using thick clay cylinders that overlap as they circle the pot. As each layer is completed, it compresses onto the layer below. Careful curing takes place as the pots are built, and after drying the amphorae are fired at temperatures of about 1000°C. As per figure 13, all thickness and measurements are approximate as each amphora is handcrafted. The cross-section amphora in figure 13 shows the typical shape, but also the modern addition of a lid that is screwed down to limit exposure to air. Both Artenova and Cotto Manetti produce amphorae from Impruneta terracotta clay, which is specific to Ferrone, a geographical area in Tuscany, Italy. The terracotta clay is revered for the specific colour, which is substantially darker than the clay used for pottery and amphorae from other Italian manufacturers, and other geographical areas in Italy. Artenova is internationally acclaimed for terracotta amphorae but also started producing terracotta egg-shaped fermenters in April 2017, with the first eggs sold in Italy in 2018. The new line has airtight terracotta lids, designed by Florentine designers Mattia Pistolesi and Jacopo Francesco. The airtight lid design was necessitated by winemakers wanting less oxidation and evaporation loss through the lids, which traditionally was sealed with wax for a tight fit after fermentation completion. All wine fermenters produced by Artenova from 2020 have these lids. 2020 sees the pilot for these airtight lids, so no research as to how the lids impact fermentation, maturation, micro-oxygenation or evaporation is available.

TAVA is a terracotta amphora manufacturer from Italy, with the only amphorae with regulated micro-oxygenation. Unlike Artenova and Cotto Manetti, TAVA does not use pure terracotta clay, but a patented mixture of terracotta and ceramic clay which can withstand higher firing temperature of between 1200°C - 1260°C, resulting in a less porous vessel with lower levels of micro-oxygenation. The buyer can stipulate the level of micro-oxygenation required, and amphorae are manufactured and fired to achieve specific porosity. "…amphoras can be customized with levels as low as 0.4 mg/L/month and as high as 10 mg/L/month" (Passin, 2019).TAVA is currently the only amphora manufacturer that produces an amphora with front drainage, as amphora traditionally has a bottom hole sealed with a bung.

Extensive research is continuously done by Artenova and TAVA to establish the effect of terracotta on wine. The Edmond Mach Foundation of San Michelle, Adige, Italy does all TAVA research. A current study is underway on micro-oxygenation using twenty amphorae with five different grape varieties and with two different porosities (TAVA, 2019). Artenova has an agreement with the University of Florence for their research on amphorae. During a study at the University of Florence completed in 2016 on "The Influence of fermentation and refinement in terracotta jars on the characteristics of wine" (Martellini, 2018) found that lighter coloured Italian amphorae are more oxidative and 17.7% more porous than darker coloured amphorae. This result reiterates comments by Savage and Sadie that each amphora has a unique character, and each delivers a wine that is subtly different from the wine in the amphora next to it. "It makes elegant wines that are representative of site climate," says Duncan Savage (Savage, 2019). The temperature regulating property of terracotta is a major benefit to slow down fermentation for better development of fruit esters, as is typical with slower fermentation (Hayes, 2015). As an example; grapes ferment for around 30 days, with peak temperature around 20°C in clay; while the same grapes in non-temperature controlled oak or stainless steel finish faster, at around 11 days, with higher temperatures of around 30°C, resulting in a lower ester levels (Martellini, 2018). Terracotta has a faster uptake of oxygen, as the vessel is more porous than oak, stainless steel, concrete or ceramic. A study by the University of Florence on Terracotta vs New Oak Barriques with regards to Oxygen transfer rate, the following findings were recorded: (Armanino, 2015)

Terracotta = 20 mg O_2 /L/month

Oak barriques = 5 mg O_2 /L/month

With terracotta, it results show that tannins polymerized faster, due to the higher oxygen transfer rate, resulting in wines with advanced texture maturation and pure expressions of fruit flavours (Armanino, 2015). These findings are supported by Eben Sadie, who uses only local clay amphorae and Nomblot eggs for his Palladius white blend (Sadie, 2019). The white varieties at Sadie wines are left in amphorae for up to 11 months before moving to large Foudres for another year.

Sadie Family Wines, Avondale, Wildehurst, Constantia Glen and Savage wines use both International suppliers and local potter, Yogi de Beer for their amphorae. All these winemakers agree that as Eben Sadie says: "It is about returning the wine into the earth, it came from" (Sadie, 2019). Yogi De Beer, in contrast to Artenova, only started making amphorae in 2006 when Duncan Savage, then Cape Point Vineyards, approached him regarding making 'neutral' wine vessels. "The idea was to move away from oak barrels, which heavily influences the flavour of the wine. One does not always need the taste of a tree in France," said Savage (Savage, 2019).

De Beer does not use terracotta, but local clay, sourced primarily from coastal areas. The stoneware amphorae are less porous than terracotta, resulting in slower oxygenation of the wines in them. The amphorae produced by De Beer does not resemble the classic ample midriff typical of Italian

amphorae, but they are slightly more elongated. He describes them as 'large wine bottles' (Stephen, 2018). Development in these locally produced amphorae includes a large plughole at the bottom to facilitate easy drainage and pomace removal. Previously the pots had to be tipped to drain the content, which was precarious due to the fragile nature of the vessel. Winemakers agree that the specific shape and clay of the amphorae produced by De Beer assist in a slow fermentation, resulting in less oxidative flavours compared to the amphorae he initially produced from imported terracotta.

Artenova, TAVA, Cotto Manetti and Yogi de Beer produce only unglazed and unlined amphorae. The slow drying and firing temperature of around 1000°C protect the pots against leakage. Artenova recommends pots filled with water before using them for wine to saturate the material and establish a ratio between internal and external moisture levels to inhibit leaking (Parisi, 2019). South African winemakers using amphorae agree with this recommendation. De Trafford recently acquired glazed amphorae, but as yet no information is available as to the wines from these amphorae.

Terracotta clay has an alkaline pH, and generally contains some levels of calcium and potassium carbonate. Both calcium and potassium carbonate can be used to lower the acidity in wines (Harbertson, T., Henick-Kling, T., 2010). Andrew Beckham, winemaker Beckham Wines, Oregon, USA, manufactures clay amphorae, which he calls Novum. He completed a series of analytical tests on how specific cultivars react in amphorae. His findings noted that clay reacts with wine and raises the pH significantly in periods as short as two months. “I took a Riesling with a pH of 2.8, and in just two months, it went to 4" (Weltman, 2018). His findings support by comments from Natasha Williams, winemaker Bosman-Adama, who remarked that the wines from high acidic varieties fermented in amphorae "has softer edges". (Williams, 2019).These results can be attributed to the calcium and potassium carbonate naturally present in the terracotta reacting with the pH levels of the wine in the vessel.

Another benefit of clay is its natural clarification properties. Winemakers not using amphorae use negative charge diatomaceous earth to fine their wines. Clay has diatomaceous earth as part of the structure, making it unnecessary to fine wines fermented or matured in clay.

Although the cost of both local and international amphorae exceeds that of a new oak barrel, the difference lies in that "oak can only be used for around seven years, while amphorae can last forever," says Anthony Hamilton-Russel (Stone, 2012).

6.2 Qvevris/Kvevris

Some people might think that using ancient technologies are a gimmick. Georgian producers and Avondale winemaker Corne Marais, fermenting wine in qvevri, would argue otherwise.

Qvevri, like Tinajas, Dolia and Talhas de Barro mentioned later, are classed as amphorae like vessels, due to the similarities of being handcrafted from terracotta clay and fired at high temperatures. Qvevris are the largest of these winemaking vessels, with an average capacity of around 1200 L. Qvevri originated in Georgia, where traditional winemaking in these vessels historically can be traced back 6 000 years. The principal differences between qvevris and other clay amphorae are that qvevris have no handles and pointed bottoms to collect lees and fermentation residue. The clay is coarser and less dense than a traditional amphora; the density a result of lower and uneven firing temperature. Qvevris are flavour neutral, with oxygen permeability similar to that of concrete.

The vessels are kiln-fired at a lower temperature than traditional clay amphorae, giving them higher porosity than clay amphorae. The higher porosity should directly relay to higher levels of micro-oxygenation. A layer of beeswax applied to the inside of the Qvevri when warm from the kiln counters the porosity as beeswax waterproofs and sterilizes the vessels, imparting subtle aromas to wine during fermentation and maturation. The waxy layer forms a smooth surface on the inside of the tank, making cleaning of the vessel easier after use.

Figure 14: Pointed bottom of Qvevri (McKirdy, 2018)

The pointed bottom cone of the qvevri acts as a receptor for grape seeds sinking to the bottom at the end of fermentation. The lees cover the grape pips and prevent any bitter phenols from developing in the wine. Traditionally qvevri are buried in soil up to the neck of the pot, due to their size. It regulates temperature, since soil at a level of 1 m, has a year-round ambient temperature of 15°C, making any extra temperature control during fermentation obsolete. The soil acts as the secondary level to temper the level of micro-oxygenation. Temperature control plays a vital role during fermentation and maturation. The thick walls of qvevri, about 40 mm, act as excellent heat exchangers and the low earth temperature absorbs the radiated heat. Due to qvevris being buried, the walls can hold a stable temperature as long as necessary for both primary and malolactic fermentation. Pressure caused by the weight of juice, skins, and pips during fermentation causes grape skins and pips to separate from the fermenting wine, assisted by occasional batonnage. "The content of malic acid in the wine diminishes, and the wine acquires certain gustatory qualities, completeness, and perfection–its unpleasant high acidity disappears" (Barisashvili, 2012). After fermentation, the must temperature falls and creates a vacuum, submerging the pomace cap and sealing the qvevri lid. The change in temperature at the beginning of autumn coincides with the end of the long fermentation, which supports natural wine clarification and tartrate removal. The extended maceration and slow fermentation cause increase aromas and flavours more concentrated than wines made in traditional wine fermenters, such as stainless steel. All qvevri wines undergo malolactic fermentation, often simultaneous with primary fermentation. The simultaneous fermentation is attributed to qvevri wines undergoing whole-berry natural fermentation and left on the lees until bottling. Malolactic fermentation plays a role in red and white qvevri wines as it tempers the medium to high acidity of varieties traditionally used in qvevri. Wine is bottled directly from Qvevri as all sediments deposits sink to the bottom of the vessel after fermentation.

Avondale, a biodynamic wine producer in Paarl, is currently the only South African wine producer using this method of winemaking. Avondale began using qvevri at Avondale in 2018. Jonathan Grieve, the owner of Avondale, sourced the qvevris from the Georgian qvevri master, Nodari Kapanadze. As can be seen in figure 15, the Qvevris at Avondale have plastic-lined, wooden lids to further minimize oxygen contact during maturation, resulting in crisp aromatics in the wines. Figure 15 shows how the vessels are buried up to the necks, with just the lids showing. Avondale uses Chenin Blanc, Grenache, Syrah, and Mourvèdre for qvevri wine. The Avondale Qvevri Chenin Blanc 2018 is described as "the clay brings a beautiful brightness of fruit and minerality to the wine" (Avondale, 2019). Avondale also has several clay amphorae, mostly from the local potter, Yogi de Beer.

Figure 15: Wooden lids, lined with plastic, used as qvevri lids at Avondale, (Avondale, 2017)

6.3 Dolium

A dolium is similar in shape but smaller than a Georgian Qvevri. It is made and used predominantly in Italy and differentiates itself from the Qvevri with a tapered but flat bottom. These clay vessels are not buried underground but used as amphorae for wines. The wide top contrasts with traditional amphorae, which is more tapered at the top. Dolia are ideal for red wine fermentation or skin-contact whites, as the larger opening at the top makes the removal of must from the juice far easier.

Figure 16: Dolium, with slightly flatter base to enable vessel to stand. (McKirdy, 2018)

6.4 Tinajas

Tinajas are traditional Spanish elongated, spherical clay vessels used for wine fermentation. Tinajas, same as Dolia and amphorae are manufactured from terracotta clay and has a similar porosity. The more egg-like shape features a wider top than amphorae or dolia and due to this seen as more oxidative than the former mentioned. Like Portuguese Talhas de Barro, South Africa does not use Tinajas yet. Alberto Nanclares is a Spanish wine producer producing La Tinaja de Aranzazu.

6.5 Talhas de Barro

Talhas are traditional Portuguese wine fermentation vessels, manufactured from terracotta clay and lined with wax to minimize leakage and contact with oxygen. It has a traditional bulbous, amphora like shape, but is very wide just under the neckpiece to allow the cap to settle. Whole-bunch fermentation is done, with punch-down to break up the cap. After fermentation, the vessels are topped with olive oil to prevent oxidation. The wine is siphoned directly from the bottom of the vessel for drinking.

As with Tinajas, Dolia and Qvevri, Talhas are not used extensively anywhere in the world. Winemakers, such as Luis Patrao in the Alentejan area of the Iberian Peninsula, are experimenting with wines produced in these traditional vessels.

6.6 Differences between Qvevri and Amphorae

- Although both are made from clay, there are significant differences that impact on labour and cost.
- Qvevris are buried, resulting in consistent temperature. Amphorae are free-standing, so high external temperatures impact on amphorae, which have to be cooled down with water, coating the external surface. Not managing the external temperature in an amphorae cellar, can result in excessive evaporation from the vessels, leading to more oxidative flavour in the wine.
- Qvevris are drained from above which necessitates pumps while amphorae are drained below with natural, gravitational filtering.
- The thick, reinforced walls of Qvevri make them less likely to break, while amphorae are fragile. Winemakers often refer to accidents with forklifts.
- The amphorae are lighter in weight and can be moved around. Qvevris are built into the ground of the cellar, which necessitates prior planning.
- Qvevri whole-berry fermentation creates challenges to clean, due to working downwards and using specialized equipment. Amphorae are easier to clean as bottom drains aid in easy removal of pomace from the vessel.

7. Food grade, high-density polyethylene (HDPE)

As discussed, concrete eggs and clay vessels have become popular in recent years amongst lateral thinking winemakers. Unfortunately, the difficulty of transport, debilitating cost, and challenging installation do not always make this a viable option. Traditionally plastic tanks or flow bins made from opaque food-grade plastic are only used in wineries when space in stainless steel and oak has been exhausted. Against this background, several high-density polyethylene wine fermenters were developed. The significant criteria development criteria are:

- The perfect natural egg shape
- Made from food-grade, high-density polyethylene plastic
- Non-transparent
- Sturdy base
- Ability to use strong chemicals and very hot water to clean tank
- Completely sealable and fixtures, such as gasketed manways, which are sealable, yet removable for ease of cleaning

Innovations in plastic tanks are now available, especially for small to mid-size wineries. The use of high-density polyethylene (HDPE) tanks, alone or in combination with oak alternatives are regarded as potential inexpensive alternatives to barrel ageing. According to the manufacturers of permeable HDPE tanks (Augustyn, 2016; Flexcubegroup, 2018; Flextank, 2016), the tanks can be manufactured with controlled permeability levels to oxygen, providing an alternative way of oxygen incorporation into wines. The tanks are oxygen permeable because of the polymers used in the construction, mimicking a 2-year old oak barrel (Carey, 2015) and enforced by the pressure difference between the in- and outside of the tank. New oak barrels measure an oxygen transfer rate of 10 - 28mg/L of oxygen per year, comparable to HDPE which measures in the upper range of 28mg/L - 35mg/L of oxygen per year (Carey, 2015). From a non-scientific perspective, this is relays to a similar mouthfeel as wines traditionally matured in barrels. Findings by a study at the University of Madrid (Del Alamo-Sanze, M., Laurie, F., Nevares, I., 2014) on the sensory attributes of red wines fermented and matured in HDPE tanks, are supported by South African winemakers using such tanks. Winemakers reported sweeter tannins and a long finish on barrel matured wines, but better colour extraction on red wines matured in HDPE tanks (Visser, 2019; Williams, 2019). Figures 17 and 18 (Del Alamo-Sanze, M. Laurie, F., Nevares, I., 2014) support opinions of South African winemakers with regards to oxygen permeability and aromatic development of wines in HDPE vessels with wood staves, and wooden barrels.

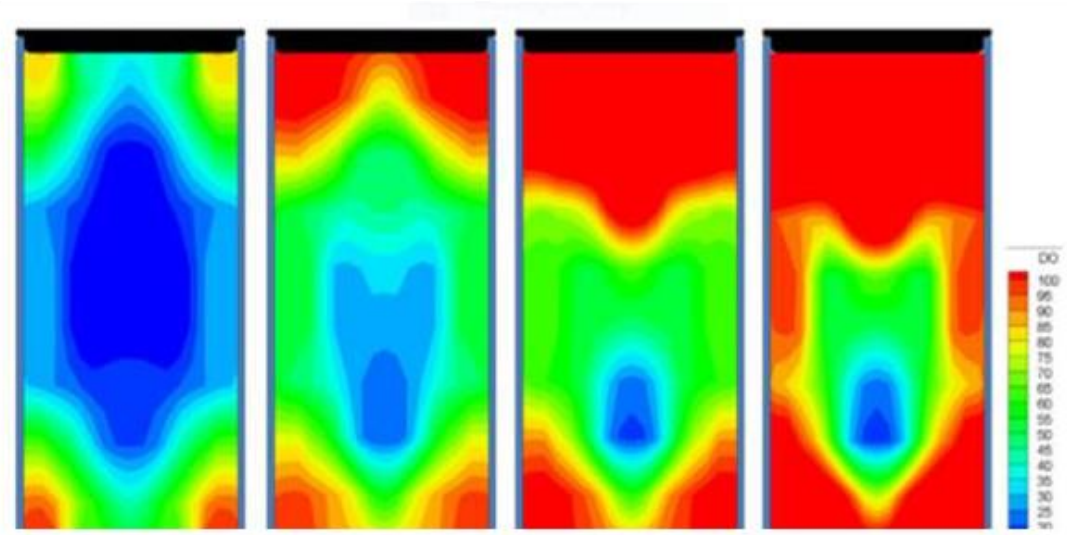

Figure 17: Dissolved oxygen mapping in HDPE tank at different time intervals;500, 1000, 1500 & 2000 minutes. (Del Alamo-Sanze, M. Laurie, F.,Nevares, I., 2014)

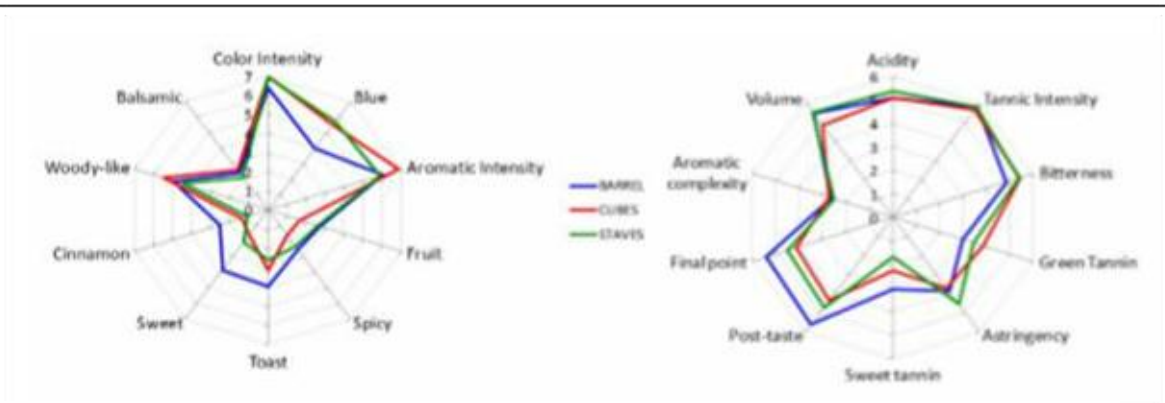

Figure 18: Aromatic profiles of red wines aged in different systems. (Del Alamo-Sanze, M., Martinez-Gil,A.M.,Nevares,I.,Sanchez-Gomez, R., 2018)

There are numerous reasons why specialized plastic tanks are attractive to the wine industry. They are designed especially for use in the wine industry; mostly making maximum use of space, as the weight makes the vessels stackable for storage when empty, but also stackable on a shelving system when filled. Some wineries use tanks inside during harvest for fermentation and maturation and stored outside for remainder of the year. This enables winemakers to use this space for bottling or other purposes. The tanks are environmentally friendly as it does not have a limited life span, such as wooden barrels, ensuring a lighter long-term carbon footprint for the winery.

The advantage of plastic over stainless steel is the flexibility of the material and the relative strength thereof compared to a stainless-steel tank. The flexibility of the plastic tank, the same as a wooden barrel, allows changes in volume based on the change in temperature of the internal and external temperature of the direct environment of the tank.

Unlike stainless steel a plastic tank can be fitted and sealed with gasketed and clamped manways, allowing no oxygen into the tank via openings, ensuring rigid control over SO_2. Stainless steel does not have this flexibility and stainless-steel tanks will implode or buckle if sealed during fermentation.

Polyethylene tanks offer interchangeability from using it for red or white wines, due to the smooth internal surface of all these vessels. High-density plastic does not absorb colour, making it an extremely versatile product. Several winemakers use plastic tanks for fermenting, and maturing wines, although their effect on the chemical and sensory properties of wines have not yet been researched. The ease of using oak adjuncts allow winemakers to create wines similar to traditionally wood matured wines. Del Alamo, M. et al. concluded: "that wines aged in HDPE tanks with wood pieces have properties quite similar to wines aged in wood barrels" (Del Álamo, M., Nevares, I., Cárcel, LM., Crespo, R., Gonzalez-Muñoz, C., 2010). The most significant contributing factor to switching to plastic is the cost, as these tanks provide significant cost savings. Plastic tanks save space, money and trees, compared to stainless steel and wooden barrels. All of the manufacturers discussed offer HDPE tanks that are fully recyclable on both the plastic used as well as the metal fittings.

7.1 Flexcube

"The concept is straightforward: oxygen permeable polymer Flexcubes containing wine are coupled with true barrel oak, the same oak used to make traditional oak barrels. We put the oak in the wine, not the wine in the oak" (Flexcubegroup, 2018).

Launched in Australia in 2001, Flexcube is used extensively in the South African wine industry. Wine producers using the stackable system, include Orange River Cellars, Bosman-Adama Wines, Hartenberg, Kaapzicht and Durbanville Hills.

The square, polyethylene blocks are also referred to as New Generation Barrels, as it resembles oak barrels in its oxygen permeability and traditional wood flavours imparted to wines. Flexcube offers a solution to wineries wanting complete control over the oaking regime. Staves used with the Flexcube system originates from a cooperage in Charentes, France. The cooperage produces staves specifically for use with Flexcube, known as BarriQ, but also produces barrels under the Oak Masters Selection brand. BarriQ staves are available in 8 different 'barrel blends' (Flexcubegroup, 2018) and are harvested and cured in the same way as traditional barrel oak. The advantage of Flexcube staves is the consistency year after year, which cannot be offered by traditional coopers that show variables from one year to the next regarding levels of wood aromas. By using staves, and not completed barrels, all sides of the wood are exposed to the wine, resulting in more effective uptake of flavours. Flexcube aims for a more responsible approach to the use of oak in winemaking. This sentiment is echoed by Flexcube South Africa Technical Sales Manager, Bertus Fourie, who believes that how we view wood maturation in wine, is changing internationally((Augustyn, 2016). PEFC, an international forestation certification system, certifies all Flexcube oak.

A case study in the Napa Valley (Flexcube, 2015) showed that Flexcube delivered exact results in comparison to oak barrels, but over a more extended period, pointing to slower flavour extraction. It is a cost-effective system that replaces the traditional oaking through barrel regime. Inhouse research at Flexcube Australia has shown the vessels to be as permeable as barrels. It offers identical results to traditional barrels (Flexcubegroup, 2018), and as proven by the Napa Valley case study, at a fraction of the cost of traditional barrels.

Winemakers using Flexcube specifically comment on the flexibility the product offers (Flexcube, 2015; Williams, 2019). The range offers cubes with different levels of permeability, which aids the winemaker in controlling the levels and speed of the maturation of the wine. Wayne Donaldson, winemaker Donaldson Wines, Napa Valley, USA, said; “When I think about the Flexcube concept and its relationship to barrels, Flexcube is essentially deconstructing what a traditional barrel does and reconstructing in a form that is much more flexible, much more adaptive and much more agile when it comes to the winemaking process" (Flexcube, 2015). Wilhelm Coetzee, winemaker Durbanville Hills, commented that Flexcube is more effective with regards to topping levels, as external humidity and temperature do not have the same influence on Flexcubes as on barrels. "With barrels constant temperature and humidity is a deciding factor on the eventual quality of your wine, with Flexcube not at all" (Flexcubegroup, 2018).

7.2 Speidel

Speidel Fermentegg, manufactured by SPEIDEL, Germany, was the first polyethylene wine egg on the market. It is the only polyethylene tank that meets FDA (US) & EU Food Safety Regulations (Speidel, 2016).

Extensive research and development have yielded evidence that the vessels have an oxygen permeability similar to a second fill barrel (Miller, 2019; Speidel, 2016). The egg, due to its relatively high level of oxygen permeability, in comparison to other polyethylene tanks, can be used as a maturation vessel for wine that benefits from further micro-oxygenation during maturation. The small sizes,200L and 600L, makes this vessel ideal for boutique wine farms, garagiste or winemakers experimenting with varieties or wanting to ferment small individual batches as blending partners for wine. As per other ovoid wine fermenters, a torus vortex forms during fermentation keeping lees in suspension. SPEIDEL also manufactures the Fermentegg in a flat-based version, to which they advise integrated cooling added at an additional cost, due to the high-density of the polyethylene. This aids for better management of temperature spikes during fermentation.

7.3 Zeppelin

The Zeppelin wine egg was conceptualized, designed, and manufactured in South Africa. Retief Krige, industrial designer, and Krige Visser, winemaker Arcangeli, and Pieter de Waal, winemaker Hermit on the Hill collaborated on the design of the Zeppelin (Retief & Visser, 2019).

The shape of the egg, typical of wine eggs manufactured from concrete, clay, terracotta and ceramic, also features a natural conical vortex during fermentation, eliminating the need for batonnage. For small winemakers, this is an advantage as it minimizes the workforce needed during winemaking. The weight of the Zeppelin is such that it can be transported on a standard trailer and off-loaded by 2 adults, which translates to one person being able to move it around when empty. The ease of moving the Zeppelin highlights the need for less, or other use of, workforce. Similar to other HDPE tanks, the Zeppelin is smooth inside for easy cleaning, using hot water and sanitizing soap, again putting less pressure on the workforce. The low comparative price to other polyethylene eggs is the real attraction of the Zeppelin as it retails at less than R10 000 for a 600 L vessel (Retief & Visser, 2019). All other HDPE tanks are imported, which relays to higher prices due to exchange rates, transport and import duties.

Figure 19: Zeppelin base, inside and vessel with Krige Visser. (Retief & Vissser, 2019)

The first two wines which were partially made in Zeppelin, were Mount Abora Koggelbos 2017, a Platter guide 5-star, and Mount Abora Cabernet Franc (DeWaal, 2019). Johan (Stompie) Meyer and Krige Visser made both wines. The Zeppelin is oxygen permeable, although as yet no definitive research has been concluded on the levels of micro-oxygenation. Arcangeli Winemaker, Krige Visser uses the Zeppelin for the fermentation of Verdelho at Arcangeli Wines. He concluded that the oxygen permeability of the Zeppelin did not negatively influence, but rather concentrated the fresh flavours typical of Verdelho (Visser, 2019). Other winemakers using Zeppelin include Marius Malan, Malanot Wines and Rikus Neethling, Bizoe and Croydon Wines.

7.4 Flextank USA

Flextank USA has a large variety of polyethylene wine tanks to "replace your oak barrels and stainless steel" (Flextank, 2016). The Apollo, 870 L, Orion, 2000 L, and Galaxy, 5000 L, wine tanks are ovoid, which is the primary discussion in this study. The tanks are made from rational moulded high-density polyethylene with oxygen permeability similar to a neutral wine barrel. US Winemakers report fermentation the same as concrete and clay wine eggs, with a torus vortex forming naturally during fermentation (Flextank, 2016). Figure 18 shows the flat bottom, which with the lightweight of the vessels, makes it easy to move around, but not stackable without a shelving system.

The flat bottom of the Flextank USA vessels, can like the SPEIDEL Fermentegg, cause spikes in temperatures during fermentation, and the temperature control mechanism, which is an additional cost, is therefore advised.

Figure 20: Apollo ovoid vessel, note the flat base, no need for footing structure. (Flextank, 2016)

Flextank also produces a range of stackable cubes in sizes, 454 L, 910 L and 1135 L similar in look to standard cubed plastic bins but made from HDPE. This range confirms the company policy of sustainability in that it fits into standard crating systems, which can be purchased second hand. The Stackers are predominantly used for storage and not explicitly intended for fermentation or maturation. Other HDPE tanks shapes manufactured by Flextank USA include Flextank cells, suited to narrow areas; Dexter, drum-like vessels with clamp lids and a maximum size of 1135 L;

and Eco, similar in look to Dexter, but offering a large top opening for easy cleaning, and managing wood adjuncts. The Eco range aims at tiny producers, as the sizing range from 57 L to the largest vessel of 1135 L.

	Oak barrel	Cement Egg	Terracotta	Stainless-steel tank	Square Plastic	Apollo	Speidel	Zeppelin	Other HDPE tanks
Cost	High	Extremely High	Extremely high	High	Affordable	Very high	High	Affordable	Affordable
Transparency	Not see-through	Not see-through	Not see-through	Not see-through	Translucent	Not see-through	Not see-through	Not see-through	Mostly translucent
Shape	Oval	Egg with vortex	Sphere like	Round/Square	Square	Not true oval, flat bottom	Egg with vortex	Egg with vortex	Multiple shapes
Storage	Can be stacked	Heavy & Static	Heavy & fragile	Heavy & static	Light, stackable	Light, not stackable	Light, not stackable	Light, not stackable	Light, some stackable
Space	Vertical	Horizontal, space-eater	Horizontal, space-eater	Horizontal, space-eater	Some vertical stacking	Some vertical stacking	Horizontal, space-eater	Horizontal, space-eater	Some vertical stacking
Hygiene	Tricky	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe
Durability	Medium	Long term	Long term	Long term	Long term	Long term	Long term	Long term	Long term
MOX	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Oxygen permeable	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Temperature Control	No, reliant on Favourable ambient temperatures	Excellent Insulator	Clay an Excellent insulator, Evaporation Equilibrium	Yes	No, reliant on favourable ambient temperatures	Can be included at additional cost	Can be included at additional cost	Can be included at additional cost	No, reliant on favourable ambient temperatures
Fermentation	White wine	White & Red wines	White & Red wines	White & Red wines	Not at all	Mostly white	Mostly white	Mostly white	White & Red wines
Maturation	White & Red wine	White & Red Wine	White & Red wine	Mostly white	Not at all	White & Red wine	White & Red wine	White & Red wine	White & Red wine
Evaporation	Losses incurred	Minimal losses	Minimal losses	No losses	No losses	No losses	NO losses	No losses	No losses

Table 1:Comparison of vessels discussed

8. Wood ovoid tanks

Taransaud and Founderie Francois are at present the only manufacturers of wooden wine eggs. The ovoid shape is the same as those of cement wine eggs, but much more expensive, around R400 000 for a 2000 L vessel, and does not have the longevity of a cement wine egg. At present, there are less than 20 of these wooden wine eggs in the world with Champagne house, Drappier buying one of the first ones, and using it for fermentation of Chardonnay. The benefit of a wooden egg is similar to a cement egg; with minimal human intervention due to natural movement during fermentation and transfer of oxygen due to porosity of the oak. In contrast to the neutral flavour cement, the oak of the Taransaud Ovum and Founderie Francois wooden wine egg adds typical new French oak flavours to the wine.

9. Consumer reaction to alternative wine vessels

A short survey with winemakers, retailers and wine consumers show agreement that information on these vessels is key to making these styles of wines more acceptable to the general wine consumer. At present wine retailers are reluctant to stock these wines as the average wine consumer, who does not have the relevant information around these wines, do not buy these wines. Specialist wine retailers aid in introducing these wine styles to consumers as there is, in most cases, gained trust in the trade relationship. Wine trends, on-line sources and social media help to make these wines more acceptable. However, only the curious wine consumer who reads these specific sources is exposed to the knowledge behind and possibly buy these wines. The low eventual carbon footprint and sustainability, together with consumers wanting a healthier lifestyle, can assist in the marketing of these wine styles. However, again only a certain percentage of possible buyers react to this marketing. The focus of this study is not on consumer reaction to alternative wine vessels. However, for the sake of the acceptance of these wine styles on a general wine shelf, it was beneficial to test the reaction of specifically wine retailers and wine consumers and to conclude that the general wine consumer is uninformed with regards to these vessels, but open to information when presented to them.

10. Conclusion

This study did not aim to ascertain the value of one specific type of wine vessel but was instead an investigation as to what is currently available other than traditional Stainless Steel and wooden barrels, and what results winemakers are achieving with these vessels. The study has shown that a growing number of winemakers are experimenting with alternative wine vessels, striving to create wines that show the real character of the grape, more than the flavour influence of the specific vessels used. Investigation through interviews with winemakers, both South African and international, show that winemakers want the expression of cultivar flavour. They investigate ancient vessels and winemaking techniques with the support of proven scientific principles, such as suspension of lees in ovoid-shaped vessels due to the formation of a torus vortex (Calvert, 2017; Carey, 2015). The neutral flavour of cement, terracotta, ceramic and HDPE, together with the even transfer of oxygen into these vessels, as per winemaker interviews (Barnard, 2019; Elphick, 2019; Savage, 2019), but also by investigative studies (Blaauw, 2019; Del Alamo-Sanze, M.Laurie, F., Nevares, I., 2014) confirm that expressing of grape and terroir is possible as per what winemakers are trying to achieve, with these alternative wine vessels. Micro-oxygenation is a valid claim with all alternative wine vessels, whether engineered to a specific level or just because of the inert material.

I believe that this study managed to investigate examples of alternative wine fermenters and maturation vessels that are available to the South African winemakers. It has shown that the majority of these vessels are used either by smaller wine producers or as a supplementary to add complexity to large-scale production. Sustainability and a lower carbon footprint, by using, for example, Flexcube with BarriQ staves (Flexcubegroup, 2018) or using locally produced HDPE Zeppelin (Retief & Vissser, 2019) tanks also play a role in choices made by some wine producers. The reduction in labour, due to weight, specific to HDPE tanks; and no need for batonnage, due to formation of torus vortex in ovoid tanks; influence decisions by winemakers as to what wine fermenters and wine maturation vessels to buy.

Limitations experienced during the research were two-fold. Although some of these vessels, such as qvevri and amphorae, were used thousands of years ago, it has only become fashionable again in the last 20 years. Research results on the majority of these vessels are limited, and on-going research has not yet rendered results. South Africa has no completed research on any of these vessels, and due to my non-academic background, international universities were reluctant to make research available to me. Interviews with South African winemakers were challenging to facilitate, as winemakers, specifically from more extensive cellars using these vessels, could not make information available to me, due to time constraints and legal obligations to their place of work.

Although this study investigated alternative wine vessels, more technical research on specific vessels will be advantageous to the wine industry. Sustainability and carbon footprint of these vessels and the knowledge thereof, on the wine consumer, can offer a different insight into the impact these vessels might have in the next 20 years, as it becomes more commonplace in production. The questions of sustainability and carbon footprint validate the use of most of these vessels. However, transport, due to majority international suppliers, is still to be weighed against carbon footprint and the longevity of these vessels. The effect of these can be in independent academic study.

In my opinion, there is a definite place for all wine fermenters, both ancient and contemporary, as it allows winemakers to showcase specific wine styles.

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List of figures

List of Tables

Appendices