

# BOTTLE CLOSURES

## IN

## THE

# WINE INDUSTRY



**BERENICE BARKER**

## INTRODUCTION

Archaeological evidence shows that in the lush crescent around the Mediterranean, wine has been made for millennia. Wrecks of very old ships on the sea bottom that have been explored revealed amphorae that were used to transport – and presumably also store – the two forms of ‘liquid gold’ of the ancient world, olive oil and wine.

Of pertinence to this study is the requirement of effective closures. Storage over quite long time periods must also have shown the advantages of ageing of wine, which again demanded effective closures for the containers. The use of cork has been traced to Roman and Chinese times, with certain literature denoting its use as a wine jug stopper in Greece in 500BC. Prior to cork, bottles were closed with wooden bungs wrapped in hemp. And before that, olive oil was floated over the top of the Egyptian amphorae to be replaced by pine pitch as the sealant. The cork stopper as we know it today was first applied to wine bottles by Dom Perignon in 1670.

The treatment of wine during storage and for transport has come a long way since then. Demand from consumers for a quality product and competition between producers and marketers of wine over the centuries have triggered innovative solutions. Advances in technology enhanced the closures that were available, and contributed to the invention of new closures – which were not always enthusiastically received.

The wine industry and consumers are fairly traditional and conservative and do not readily respond to innovation. Yet today we are standing at the threshold of more improvements, particularly in closures, than at any time during the past two hundred years. Ultimately the stopper has to be a reliable seal, one which is an inert substance to the wine and which can easily be removed. Its appeal is greatly enhanced if the stopper is able to be produced at a relatively low cost.

The wine industry being as dynamic as what it is will always be subject to change and modernisation. It remains an unknown as to the acceptance by the consumer market as a whole for alternative, and likely cheaper, closures. A far greater question lies in the acceptance by wine makers and marketers to embrace the alternatives. Or might the traditions and the aggressive marketing campaigns in support of natural cork triumph, and the status quo remain unchanged.

# CONTENTS

INTRODUCTION	pg 2
CONTENTS	pg 3
CHAPTER ONE – NATURAL CORK	pg 4-22
1. Chapter introduction	
2. Production of cork stoppers	
3. Overview from bark to bottle	
4. Tri-chloro-anisole	
5. Wine faults	
6. Bottling issues	
7. Natural cork and wine ageing	
8. Research and survey reports	
9. Summary	
CHAPTER TWO – SYNTHETIC CLOSURES	pg 23-31
1. Chapter introduction	
2. Advantages and disadvantages	
3. Production of synthetic closures	
4. Consumers issues	
5. Storage and bottling guidelines	
6. The South African perspective	
7. Summary	
CHAPTER THREE – SCREW CAPS	pg 32-45
1. Chapter introduction	
2. A brave new closure	
3. Technical specifications	
4. International applications	
5. The South African perspective	
6. Changing the paradigms of cellaring	
7. Summary	
CONCLUSION	pg 46
REFERENCES AND ACKNOWLEDGEMENTS	pg 47

# CHAPTER 1

## NATURAL CORK

### 1. CHAPTER INTRODUCTION

The use of cork as a stopper was employed by the ancient Greeks whilst a wide variety of airtight stoppers were used by the ancient Egyptians in sealing their amphorae. Writing in the second century, the Roman author Cato comments on the sealing of jars in which there were incomplete fermentations with cork and pitch. The use of cork however does not appear to have continued into the medieval area - the postulated reason is that the main supply area was that from the Iberian peninsula which had been conquered by the Moors in the eighth century. Barrels were generally sealed with a wooden stopper and a piece of cloth was placed between it and the barrel so as to provide a more airtight seal. Pitch and wax often being used to provide further protection.

New methods of stoppering were embarked on during the seventeenth century with the development of glass bottles. Glass stoppers which had been ground to fit individual bottles and tied to them with thread, were used. However these stoppers were expensive and after much trial and error and with the introduction of cork, were disbanded. Early seventeenth century corks were fashioned so as not to be pressed completely into the bottle and so could easily be pulled out without excessive difficulty. This was primarily due to the non standard size of the free-blown bottles' neck sizes.

By the end of the seventeenth century, the development of the corkscrew enabled corks to be fully inserted into the bottle neck. The mould-made cylindrical glass bottle which evolved in the eighteenth century allowed for the storage of bottles horizontally and in bins. These practices also allowed for the keeping of the cork moist and are indeed practices which have been undertaken over the last two centuries. (1)

Wine bottles have been sealed with a variety of closures, to enable bottling of the product, its transportation and storage. Cork bark became the pre-eminent choice from the 1700's onwards following Dom Perignon's successes. The growths in wine production and consumption, especially over the past several decades, have placed pressure on the growers and producers of cork bark closures. Indeed, the worldwide 'shortage' over the past ten years was attributed to the American producer, E&J Gallo, reverting to cork. Given that the cork tree prefers growing in the limited geographical region of the Iberian peninsula and that a minimum of 25 years is required before wine stopper quality cork bark can be harvested, good quality corks have and will continue to be a sought after commodity.

## 2. PRODUCTION OF CORK STOPPERS

### I. THE CORK FORESTS

Cork forests cover an approximate 2.2 million hectares of land in Portugal, Spain, Italy, France, Tunisia, Algeria and Morocco. Portugal alone accounts for 725 000 hectares, representing 30% of the world's plantations; producing more than half of the world's cork. (2000 World Congress on Cork and Cork Oak statistics). A greater emphasis on forest management and the reforestation programme in place will ensure the continued flourishing of *Quercus Suber* in the Western Mediterranean basin for many years to come. *Quercus Suber* is the species of oak from which cork bark is obtained. *Quercus* being the botanical genus to which it belongs.

A cork oak tree may start its life by one of two methods – either under controlled nursery conditions or natural germination of an acorn. The tree has a very slow and gradual growth pattern. It needs a lot of sunlight, relatively little rain, a degree of humidity and can grow up to 1400m above sea level.

The tree itself and the care of the soil are the two basic divisions of cork oak husbandry. The soil is tilled periodically with the undergrowth being cleared out every four to five years. These practices enhance the cork's economic value (in terms of quality and quantity) as well as increasing the tree's vigour. The forest's density is regulated by selective thinning and removal of aged trees. Not unlike viticultural practices, pruning is also undertaken to train young trees, maintain the form and vigour of mature trees and revitalise older trees.

In Portugal, trees may not be felled without permission (jail sentences face those who fell a tree without authorization) and they may only be stripped every 9 years, the cycle used to be every 12 years. As the cork industry is of such importance to Portugal's economy, strict regulations are in place for the management and regulation of cork oak trees. A greater prominence has also been placed on forest management by the plantation owners, which is a direct result of the increased pressure placed on them by cork producers. Annual worldwide cork production is estimated at being 12 billion stoppers – inclusive of agglomerates and sparkling wine corks.

The conservation angle is one which is being heavily played upon by the cork producers. The British based Royal Society for the Protection of Birds (RSPB) is leading an international campaign to reject the use of plastic closures. The endangered Spanish imperial eagle is one of 42 species dependent on the vast cork oak forests. Forests which may well disappear if the economics of the cork industry are undermined. The RSPB is also lobbying retailers to state on wine labels which closure has been used, so as to give consumers the choice.

The cork oak forests are mainly situated in Portugal's southern province of Alentejo. They make for the most appealing of all forested landscapes in that whilst they are vast, they are not dense so providing open woodlands for livestock grazing, offering a plethora of trees to support a remarkable bird population as well as sustaining an abundance of living creatures.

The forests provide the quintessential example of sustainable farming, in what is essentially a primeval forest. The trees are protected by law in Portugal. The potential repealing of the law is what most local conservationists fear. As the retraction of the law might well be sought by the farmers so as to remove the oaks, to make way for planting any crop which will enable them to make a living.

There are various international cork recycling programmes with the Girl Guides in Australia and the United Kingdom including cork recycling into their Guides environmental badges. Tesco's natural cork recycling initiative for Red Nose Day in March 1999 is quoted as being amongst the most successful, in raising awareness of recycling, as well as funds for charity. ([www.corkfacts.com](http://www.corkfacts.com))

## **II. CORK STOPPER TYPES**

Amongst the international major cork producers, there is very little difference in the actual steps in processing a cork. The intricacies vary between production plants as does the terminology to describe the product. With this in mind, the author has selected to detail the various stopper types and indeed most of the processing techniques from the point of the world's largest cork producer, Amorim – responsible for a quarter of the approximately 12 billion corks produced annually. (2)

The wine bottle stopper can be either a whole, natural cork (fashioned from one whole piece of cork bark) or a technical cork (consisting of high quality granulated cork with end discs of fine natural cork). There are also different corks for fortified and sparkling wines.

Two recently launched closures interestingly rely on a barrier between the cork bark itself and the wine. The French Cortex stoppers branded as Preserveur rely on a coating of silicone. The manufacturers, who are focusing their efforts on the Anglo-Saxon markets which they consider more interested in improved corks, budgeted for sales of 500,000,000 for 2003. Ultracork, which was produced in conjunction with the UK-based drinks giant Allied-Domecq also has a polymer coating, but also boasts an ultra-sound treatment to clear the cork of TCA.

### **a. Whole natural cork**

These types of cork are punched out from a single strip having been graded as being of superior quality. The stopper is punched out as a whole item, either manually or by machine. The higher quality grades of corks would originate from a finely structured whole piece of cork bark with minimal imperfection. The longer the cork, and the fewer flaws; the higher the quality and the greater the price.

The basic substance of cork is Suberin – a mixture of fatty acids and heavy organic alcohols. The suberose sacs make the cell membrane impermeable and airtight. The average composition is: (APCOR fact sheet 2002)

1. Suberin 45 % : contributes to the resilience
2. Lignin 27% : binding compound
3. Polysaccharides 12% : cell wall components which define the texture
4. Tannins 6% : responsible for colour
5. Ceroids 5% : hydrophobic compounds ensuring imperviousness of cork
6. 4% : mineral water, glycerine balance

b. Technical cork

These are stoppers which consist of small pieces or granules of clean, natural cork bound together with resin or a chemical binder. One or more discs of intact natural cork are stuck on the end intended to be in contact with the wine.

Amorim produces two types of technical corks, Spark® for champagne and sparkling wines and the Twin Top® for still wines for short to medium storage. Efficient use is made of natural raw material for their production. While retaining much of the tradition and quality that wine drinkers associate with cork, these are not recommended for long term cellaring

c. Sparkling wine cork

These are made from a single moulding of high quality natural granulated cork. At one end there are two or three discs of fine natural cork. Natural cork is punched whole from the best quality bark as the discs on the end are in contact with the liquid.

d. Colmated cork

Lower grade natural cork with larger lenticels and structural imperfections, is used to make colmated corks. They are coated with a mixture of fine cork particles and natural latex to seal the surface of the cork and improve its performance as a stopper.

### 3. OVERVIEW OF FROM BARK TO BOTTLE

It was indicated previously that there is very little distinction between all the producers and the actual steps undertaken in producing a natural cork. The following synopsis is to give the reader a brief overview of the process, elaborating more detail further on.

- The outer bark is harvested May to August – stripped from designated trees
- The bark is opened vertically, twisting the axe to separate the outer from the inner
- The plank is removed from the tree – the larger the plank the greater the value
- Six month outdoor seasoning to stabilise
- Boiled to reduce micro flora, expand lenticels and enhance pliability
- Dried and rested in warehouses. Planks trimmed to rectangular shapes
- Quality sorted based on porosity and structural defects
- Planks cut into strips and stoppers punched out – ends cut and polished
- Leftover pieces processed into agglomerates
- Stoppers scanned and graded – use made of automated optical scanners
- Washing and disinfection process – stoppers dried
- Final manual selection prior to branding – graded in quality categories
- Final paraffin or silicone coating
- Automated counting, packaged into gas barrier bags and sanitised with sulphur dioxide

#### I. HARVESTING NATURAL CORK

Harvested from the living bark of the *Quercus Suber* oak, natural cork is a highly renewable resource. The cork oak is the only tree which is able to regenerate its bark. A 9 year cycle is in place in Portugal so as to promote the healthy growth of trees over their expected lifespan of 200 odd years. Numbers are painted onto the trees to track the stripping process. It is only into the third cycle of the trees growth that the bark is stripped for wine cork production. As such, the farmer has invested 40 years to reach this point. The first crop, virgin bark, is stripped at 25 years old but is unsuitable as cork for wine bottles. It is only after the completion of the third cycle that cork is deemed suitable for stoppers. The famous Whistler tree in Portugal (named for the numerous singing birds attracted to it) is now over 213 years old; it was estimated that at the end of 2000, over 1 million corks had been produced from the tree.

Cork bark is harvested in the spring or summer months as at this time of the year the cork comes away easily from the trunk. Should there have been droughts; the trees are less willing to give up their bark. The bark is cut away from the tree with surgical precision. The forestry workers make a vertical cut, at a height often just above their heads, with the razor sharp blade of an axe. The axe point slips through the black, inch thick bark as the worker feels for the trunk underneath. He follows the first cut with others in a descending line down to the ground. At this point, the bark has been ‘unzipped’ from the trunk. The wedge shaped end of the axe shaft is used to lever the bark off.



It comes away cleanly, usually in two long pieces. The very small cells which make up cork contribute to its light, elastic, resistant and impermeable character. There are approximately 40 million per cm<sup>3</sup>. Cork's sealing capacities are due to the elasticity as well as the waxes and fatty acids in its composition.

As with all facets of the wine industry, balance is the critical point and with increased interest and importance being placed on forestry management, the cork producers are working at creating balance in the trees – optimal balance of leaves, branches and cork. Their main focus is concentrating efforts into increasing quality from the source – the trees in the forest.

## **II. SEASONING AND SORTING**

The objective of the outdoor exposure (seasoning) is to oxidise phenols, purge the sap and stabilise the cork texture. Traditionally seasoned outdoors for a period of six months, this process has been revised to eliminate potential mould growth. As the planks used to be stacked on the forest floor, microbiological contamination was rife. Under the cork industry's Code of Good Practice, the planks are now stacked off the ground in the yard of the factory and stacked so as to maximise drainage and aeration of the pile. Amorim's new primary processing facility at Ponte de Sôr tags and records each batch so as to enable tracing back to forest source. All roads at their factories are also tarred and use is made of stainless steel pallets to further reduce the migration of any microbiological organisms.

After being seasoned, the planks are sorted to select the high quality bark required for wine closures. The thicker bark is used for the production of whole, natural corks whilst the thinner bark is used for cork discs. Bark stripped from the base of the tree is not suitable for wine stoppers and is used in a variety of applications, from insulation sheeting through to floor tiles.

## **III. BOILING AND SELECTION**

Traditionally, planks were boiled in tanks for one hour and then re-boiled if they were selected as wine stopper material. This step was subject to much criticism in that the water was not changed frequently enough and with batch after batch being boiled in the same water, the risk of microbiological cross-infection was great. Much research and development is being undertaken and Amorim, for example, developed a new process which has been used on all corkwood since 1999. The planks are boiled in closed steel tanks fitted with a device known as a volatile compound trap. This process, referred to as the Convex process, continuously extracts volatile compounds, such as Trichloroanisole (TCA) from the washwater. ([www.corkfacts.com/november2003](http://www.corkfacts.com/november2003))

This new process differs profoundly from the old as the cork planks are boiled in smaller two ton batches and the even temperature distribution and improved water circulation boost the extraction of contaminants. It is also a dynamic system in that the washwater is pumped through a tank and then filtered to remove suspended solids. The entire water volume is filtered every 20 minutes. Non-chlorinated, filtered water is used which is regularly tested to ensure absence of chemicals.

The boiling process is not only undertaken to remove the micro flora within the bark but also to expand the lenticels and so enhance pliability. The cells expand to create a tighter and more uniform cell structure. Once boiled, the planks are stacked, dried and stabilised in a well ventilated and humidity controlled warehouse. The planks are then graded according to thickness, porosity and appearance.

#### **IV. PUNCHING AND POLISHING**

The punching out of the corks can be done either manually or automatically. Planks which contain faults or imperfections are eliminated and granulated for other products. Natural cork stoppers and disks for sparkling wine and technical corks are punched out from the best quality planks. The residue from these quality planks is used to make the bodies of other stoppers. The planks (having been re-boiled) are cut into strips just slightly wider than the final length of the cork. The strips are punched along the grain of the bark. The very best quality bark is still punched out by skilled workers who can punch up to 20 000 corks a day. An automated machine punches out around 45 000.

The corks are then polished to ensure that the ends are regular and that the stopper is the required length and even in texture. This polishing is done using an abrasive stone.

#### **V. WASHING AND FINISHING**

The process of washing corks began over a century ago. The cosmetic appeal of the cork was certainly improved in the process but it was the deep cleaning into the thousands of pores which could harbour bacteria which necessitated this process.

Washing commences after the corks have been graded for quality – ones with defects, too coarse an exterior or with visible imperfections are removed. The traditional wash involves washing of the corks in a chlorinated lime and oxalic acid solution. The cork is disinfected and a residual layer of calcium oxalate creates an acidic environment so as further to protect the cork. Safe and sound seals are produced in this way, however if done incorrectly washing can contribute to off flavours in a wine. Laboratory tests are undertaken to check the quality throughout the process.

In a quest for chlorine free washing processes, two such methods were developed in the 1980's. One option is the use of a mild hydrogen peroxide solution. The other uses potassium metabisulfite. The washwater itself can also be treated with ozone to destroy contaminants.

Amorim claim to have an innovative washing and extraction process known as INOS II, by which the interior of the cork is completely washed by pumping hot purified water into and out of the lenticels using pressure changes. After washing, the corks are dried in ovens or with sterilised air to the correct moisture content.

Following the drying stage, the corks are hand sorted to customer's specifications and made ready for relevant branding, if this is required. To ensure optimum pliability, the corks are kept in an ozone-treated humidity room. Silicon or emulsified paraffin is used to coat the cork for effective bottle sealing purposes. They are then tumbled in industrial dryers, bagged and dosed with a small 35 parts per million of sulphur dioxide to prevent contamination en route to the winery or while being stored. Cork companies across the globe, receive the batches from Portugal, perform quality control checks, de-dust the corks and then print the relevant branding for their local clientele. Traceability codes are nowadays also being printed onto the cork. An invisible food grade and ultra-violet sensitive ink is used to ensure that each cork has an identity document of its own. The corks are then ozone sterilised, surface coated and packaged.

#### ◆ OZONE

Ozone is tri-atomic oxygen. The major commercial use of Ozone is as a disinfectant and decontaminant and as a bleaching agent for waxes and oils. As the most chemically active form of oxygen, it is created naturally in the ozone layer of the stratosphere by the action of solar ultraviolet light on oxygen. Its formation in this layer prevents most ultraviolet and other high-energy radiation, penetrating to the earth's surface. It is produced commercially by passing dry air between two concentric tubes or plate electrodes connected to an alternating high voltage. Pure ozone is an unstable faintly bluish gas with a characteristic fresh, penetrating odour. Below its  $-112^{\circ}\text{C}$  boiling point it is a dark blue liquid and below its melting point of  $-193^{\circ}\text{C}$  it is a blue-black crystalline solid. (Columbia University Electronic Encyclopaedia)

#### 4. TRI-CHLORO-ANISOLE

Abbreviated to TCA, this chemical formation has become one of the most talked about and heavily debated topics over the past decade. Chloro-anisoles are a plague within the food, beverage and packaging industries. But none more so than 2,4,6 Tri-chloro-anisole with its distinctive musty/mouldy taint characteristic which can destroy a wine. The first identification of TCA in a 'corky wine' was in 1981. (3)

A dilemma has arisen where according to cork producers, the blame for anything that has, could and will go 'wrong' with a bottle of wine – is blamed on TCA and cork. Flavour modification of the wine ranks as a great concern for winemakers and marketers alike, as minute amounts of TCA which are certainly below the recognition threshold can cause a wine to be insipid, unappealing and unquestionably lacking in fruit. Inconsistent and incomplete information associated with the nature, significance and incidence of actual TCA contaminated products, remains an issue which the cork producers are tackling head on.

Albeit that there have been certain incidents over the past three years which saw cork producers being sued by several South African wine producers for having supplied inferior and infected corks which necessitated the withdrawing from the market of particular product lines.

The cork producers and none more than Amorim (as the world's largest supplier), are very ardent to rid themselves of their scapegoat status and to prove to the wine drinking world and certainly to the wine producers how few corks are indeed TCA infected these days. As well as showing how easily cork is blamed for numerous other faults, such as oxidation and volatile acidity.

#### ◆ CHEMICAL COMPOSITION

The spores of TCA are highly volatile and originate primarily in the cork forests. TCA can stem from chlorophenols in tap water or winery drains as various opportunistic moulds, aspergillus and penicillium react with chlorine in boiling water. The bark naturally contains several phenols against moulds and insects. Lenticels (the loose cells) contain nutrients and water which provide an ideal growing environment for micro-organisms such as mould, yeasts and bacteria. (Geisenheim Research Institute). By removing the phenolic precursors from the bark, there is less opportunity for TCA contamination. (Sabate manufactured a non agglomerate stopper, Altech, which replaced the wood/lignin content which harbours TCA, with synthetic cells.)

The washing procedures also facilitate the removal of precursors. TCA has a moderate affinity for cork and is not only acquired by corks from their surroundings but can be transferred from the cork by the entry of liquid vapour. When the cork is compressed into the bottleneck, liquid vapour penetrates the cork, some of the TCA migrates into the wine. While the trained nose can detect the presence of TCA at concentrations as low as 4-6 parts per trillion, confirmation requires formal analytical testing.

Taint is the unnatural odour produced by the micro-organisms. (Aside from TCA other volatile chemicals can react like sodium bromide to infect wine – sometimes from pallets and wooden materials protected by paints). Taint derived from cork, is described as a collection of microbially produced compounds loosely held together by descriptors of musty and mouldy. Taint has been reported in water, beer, fruit drinks and milk; as well as chocolate and dried fruits and other foods. Packaging certainly appears to be a contributing factor. Wood can easily be a host for TCA precursors. Any packaging material (fabricated wood) such as pallets, shipping containers, cardboard boxes and labels are suspects in contributing to environmental TCA. Changes in temperature and relative humidity in transportation can accelerate the problem. Possible media for TCA contamination in the winery include tap water, transfer hoses, filter pads, fining agents and polymeric tank liners. ([www.vwm-online.com/magazine/archive/2003/vol29](http://www.vwm-online.com/magazine/archive/2003/vol29))

Previous testing protocols involved sensory analysis of soaked cork samples to detect if TCA was present. This method had many limitations which necessitated the various producers taking more responsibility and funding research programmes and equipment which would determine the concentration of spores in the raw material. SPME (solid phase micro extraction) is a technique which uses gas chromatography mass spectroscopy to detect taint levels at 1ng/litre. This is substantially more effective than the previous reliance on sensory tests. The basic principle of SPME is that as TCA near the surface of the cork is releasable, it can be accurately measured and the potential of taint reliably predicted. These tests have to be carried out in specially equipped laboratories.

## 5. WINE FAULTS

The difficulty of identifying faults in wine, first came into focus with ‘The Harpers Debate’ in March 1999 – sponsored by Amorim Cork. A tasting was held to ascertain if the participants could correctly identify the faults. Five wines had to be assessed, four had faults and one was sound. The results proved how complicated it is, even for experts to identify the ‘defective’ wines and put a big question mark over TCA contamination claims which are not based on scientific analysis. How did they rate, these Masters of Wine, wine buyers, wine sales and marketing executives and international journalists: (Geoff Taylor Corkwise Limited March 2003)

- Not one of the 91 tasters got all five wine assessments correct
- One third failed to identify a single fault correctly
- Only one person got 4 of the 5 correct (a second year MW student)
- Only 2 tasters correctly identified the TCA sample
- 30 identified the acetic sample
- 5 identified the mould bottle
- 24 identified the sound wine
- 32 identified the oxidised sample

This exercise was repeated in October 2003 in South Africa, organised by Amorim in conjunction with Wine magazine. Blind tastings of 5 dry white wines were undertaken by 108 participants. Again, there was one sound wine, one showing oxidation, one showing TCA, one PCA\* and one with volatile acidity. And how did the South Africans fare: (4)

- 12% of the participants correctly identified all 5 wines
- 11% got the status all wrong
- Volatile acidity was correctly identified by 51%
- Oxidation was detected by 44.4%
- TCA was picked up by 24%
- PCA identified by 18.5%

\* PCA (pentachloroanisole) exhibits similar sensory characteristics to TCA, as it is a chemical compound related to TCA. However our sensory threshold to it is much higher than TCA and so can go undetected at greater levels than TCA. It is an air borne contaminant which can affect cork, barrels, filtration media and glass bottles. It is linked to wood that has been treated with pentachlorophenol based preservatives. (Columbia University Electronic Encyclopaedia)

#### ◆ Confusion surrounding taint and its incidence

Various publications and industry approximations, show a range of supposed cork taint incidents from 0.6 – 5% based on varying sample sizes of bottles of wine. Anecdotal estimates by experienced individuals range from 1 – 15%. (3). The scope of these percentages clearly illustrates the confusion which surrounds taint. There are varied detection and threshold levels, which at best are unreliable.

John Casey (former chief chemist for McWilliams Wines, Australia) proposed a structuring of the threshold categories to being detection and recognition; with the tasters being grouped as elite (winemakers/professional tasters), discerning (displaying a range of abilities and experience) and ordinary. Tasting thresholds can vary between wines, tasters and circumstances. Several of the surveys undertaken, used a small often unrepresentative sample with random clustering so as to yield statistics with little significance. But possibly the most damaging of all, is the emphasis placed on positive results.

The term ‘cork taint’ itself is misleading and a misnomer as the cork does not affect the wine; the taint is caused only when the cork becomes contaminated with TCA - which then migrates into the wine.

Taint can also occur in wines sealed with screw caps as 2,4,6 tribromanisole was found in plastic seals of screw caps from contamination by storage in wood containers treated with bromium. Some attention and the onus for taint defective wines has been deflected to bad winery practices where poor hygiene has caused moulds to grow and bacteria to infiltrate. TCA has been discovered in anything from wooden racks and pallets as well as new roofing structures. (Screw caps and other wine bottle closures Jurg Gaffner Switzerland)

## 6. BOTTLING ISSUES

John Casey highlighted the topical issue of poor bottling practices as they contribute to the closure debate. (3) Leaking corks and oxidised wine being the result of poor bottling techniques rather, than being purely a cork issue. The extensive and intimate contact by the stopper with the liquid and the bottle, requires it being a resilient and flexible material. Much is also made of the significance of head space pressure as whilst it does provide for the motive force for the expulsion of the stopper and the liquid, it can also cause the cork to soften prematurely. This happens when the cork remains in contact with the liquid whilst the pressure is high. Additional oxygen in the headspace also contributes to the oxidation of the wine. Storing bottles upright after insertion enables the pressure to subside before the wine comes into contact with the cork, thus avoiding accelerated uptake of liquid and premature cork softening.

## ◆ WINERY CORKING PRACTICES

The diameter of a cork on average is 24mm. The jaws of the corksucker compress the cork to 16mm to fit into the bottleneck. The cork bounces back to 18mm after insertion which means that 25% (6mm) is what is pushing against the glass to create the seal. The pressure the cork exerts on the glass is the important factor in preventing leaks. It is not only an aesthetic decision to use longer corks as opposed to shorter ones, but the longer ones provide better protection against leaks. Air does get into the wine during bottling but mistakes made during this process can cause leaks and premature ageing of the wine.

Modern corksuckers pull a vacuum in the bottleneck after the bottle is filled with wine. Not only does this remove oxygen from the headspace but it also prevents the headspace from being pressurised when the cork is inserted. With an insufficient vacuum, the wine can leak out between the glass and cork. Too strong a vacuum creates a negative pressure which will be equalised by pulling air in alongside the cork. Thus affecting the seal and causing the wine to be compromised.

Overfilling is yet another cause of leaking. A headspace is left between wine and cork to compensate for temperature increases after leaving the winery. This space allows for the wine to expand but if the fill level is too high, and with the slightest of temperature increases, the reduced headspace will not accommodate the expansion. Once the wine cools down and the volume contracts air is inhaled into the headspace. (5)

Criticism has been directed towards bottling procedures. The following is a brief synopsis (in point form) as to what the Natural Cork Quality Council ([www.corkqc.com/recommendedqcpractices](http://www.corkqc.com/recommendedqcpractices)) advise as being good practices to be undertaken as a responsibility of the winery.

### ▪ **Corksucker Jaw Type**

- Roller or iris type jaws can cause the cork to wrinkle and thus leak. The 4 segment sliding roller or iris jaw type cork compression system is recommended

### ▪ **Corksucker Maintenance**

- Must be maintained to manufacturer's standards
- The compression stage must be a smooth action
- No damage to the jaw segments
- Good alignment and bottle neck seal in centring bell
- Plunger properly centred
- Daily cleaning and sanitation of the hopper, feed tube, orienter and jaws
- Not compressing a 24mm cork to less than 16mm

- **Cork Handling and Storage**
  - Plastic bags containing corks not to be opened until immediately before loading into machine
  - Bags not to be left open for any reason
  - Corks recovered from corking machine to be returned to plastic bags and sulphur dioxide gas used to dose
  - Storage to be in a cool dry location, not in the bottling or barrel store areas and not near any chemical storage area
  - Humidity to be between 50 and 70% with temperatures between 12.5-20°C
  
- **Moisture Content**
  - Moisture content to be checked on new shipments as well as corks which have been stored for an extended period of time
  - Below 5% level, the corks should be discarded or returned to supplier
  - Above 8% is dangerous as such levels could support mould growth
  
- **Internal Bottle Pressure**
  - If lower temperatures than 15-20°C are used then the fill point of the bottle has to be adjusted, so as to compensate for the expansion in the bottle of the cork when room temperature is experienced
  - Bottles to be stored upright for 24 hrs after corking

## 7. NATURAL CORK AND WINE AGEING

Alternatives to cork bark have their own hurdles to overcome and whilst the cork producers remain dogged by TCA, the prospect of price increases (in part due to the supply and demand scenario as well as the increases in the costs of harvesting and processing the raw material) has to be factored in. The natural extrapolation might well be that in due course only premium wines and those intended for long term ageing will be bottled with natural cork stoppers. It would appear that within the consumers' romance and mysticism of wine, that there is the notion of a bottle being aged under perfect cellaring conditions and with a cork stopper undergoing a magical ageing process.

Tom Mackey (winemaker at St Francis Winery in Sonoma – the first Californian winery to shift entirely from cork to synthetics) is somewhat renowned for his flamboyant comments and for disregarding the need for oxygen for bottle maturation. He views cork “as being just a hunk of dead wood that deteriorates over time. The thought that this plug is allowing a tiny amount of oxygen into the wine, is frightening, it's a winemaker's worst nightmare”.

There is a commonly held view that cork is indeed essential to the long term ageing of a wine, and that the slow oxidative process generally rounds out a wine and softens the tannins. However, the following extracts are to be considered:



- Oxford Companion to Wine (Oxford University Press 1994) – the operative oxygen involved in ageing is the small amounts of oxygen dissolved in the wine during the practices of racking, topping up and later bottling. This oxygen permits polymerisation to take place so that the simpler phenolic molecules combine to form larger tannin polymers which eventually fall out of the solution as sediment.
- The Vintner's Art (Simon and Schuster 1992) by James Halliday and Hugh Johnson, explains that most of the chemical changes that take place as a wine ages is technically a reductive process. Making no mention of external oxygen uptake, they detail that the small storehouse of dissolved oxygen which is present in the wine at the time of bottling, facilitates this process.
- Auto-catalytic-oxidative polymerization is used to describe the release of oxygen molecules entrapped in the cork's pores and cells, when they come into contact with moisture. Cork being composed of tiny air containing cells is thus viewed as being a time capsule of the air that was present during the years that the bark took to grow. (Vineyard and Winery Management-online)
- Vernon Singleton (UC Davis Professor Emeritus) is of the opinion that air does get into the wine as an indirect result of wine evaporating through the cork. Water and ethanol are very small, volatile molecules which evaporate slowly through the cork, thus accounting for the increased headspace in very old bottles of wine. As the cork does not pull in, the headspace must be relieved by an inflow of air. Dry corks are permeable to oxygen, but a tightly fitting cork kept wet on the wine end will slow down the process. He is however very clear in stating that the chemical reactions responsible for bottle ageing are not oxygen dependent. (3)

## 8. RESEARCH AND SURVEY REPORTS

Research into consumer attitudes has emerged as an area of great differentiation. Varying demographics, geographical dispersion and behavioural usage purposes all offer a plethora of segmentation variable. As well as considering that many closure surveys are viewed as being skewed in the direction of the sponsor. A recent research study commissioned by the California Wine Industry quality leaders and three major cork suppliers yielded conclusions which are seemingly universal. (This was a focus group study directed at eliciting a depth of response and is thus not a statistically projectable study. Cork Quality Council Consumer Survey October 2003)

The majority of premium wine consumers perceive natural cork as being integral to facilitate the ageing process, as well as having the traditional aspects of romance and sophistication. There were very definite as well as positive opinions about the feel, sound and appearance of a good cork. Trade and consumers alike view the extraction of the cork as being a key issue. Moist and pliable corks which do not break upon extraction and so are able to be used to re-seal the bottle are highly regarded. Negative trade comments about plastic stoppers, centred on the difficulty of extraction. Other criteria mentioned in the survey were the length, coating, texture, colour and embossing. Consumers also seemed to prefer a lighter coloured cork with quality being attributed; they had a preference for graphics on the natural product as well as viewing longer corks as being of greater quality.

Visually ranking 9 corks into perceived quality categories yielded the A and B grade corks receiving over 80% positive rankings.

Natural cork is certainly viewed as having a primary function of sealing a bottle of wine, but into the mix of opinions goes its 'traditional' appeal, its ability to prevent oxidation of the wine, its facilitation of ageing, use as a re-sealant, and early warning (once extracted) of quality and authenticity aspects - logos and branding on the corks. However misguided and indeed inaccurate any one of these criteria is, they remain consumer criteria by which any number of wines is judged. The bottle closure, thus, can not fail to meet these. Over the past decade there has been much issued and exemplified in the way of statistics and indeed emotional appeals as to the validity and appeal of natural cork. At the time of writing, numerous surveys and research documents abounded which all essentially tested (to varying degrees) a certain number of bottles for cork taint as well as closure preferences by wine makers and consumers alike. Information has been extracted from several (consumer and producer related) which were most topical or indeed controversial.

#### ◆ WINE INTELLIGENCE

(Closures: The Consumer View - a full copy is attached as the appendix)

To date, possibly the most definitive survey of consumer attitudes to closures yet undertaken, was published by Wine Intelligence in the United Kingdom. The independent research survey was conducted online in August 2003 with 1,151 respondents eligible for the study, from a sample of 25 000 UK wine drinkers. The finding was clear, wine bottles should still be sealed with natural cork; consumers are not ready to give up their corks. The distinctive sound of uncorking a bottle is still a key element of the wine drinking ritual. The pro-cork attitudes which prevailed from the survey go against the recent press coverage of the benefits of screw caps and the occasional encountering of a tainted bottle.

Headline findings:

- Cork is still king with less than 1% negative sentiment
- Synthetics drew a generally neutral response
- Screw caps are viewed negatively, although there are signs of improvement
- Screw caps seen as cheap and indicative of poor quality
- New Zealand and German wine drinkers most receptive to screw caps
- Screw caps seen as better for white wines
- Higher spenders more committed to cork (tendencies weakened and even reversed for some groups)

With 99% of respondents expressing their preference for cork, the migration to screw-caps (by retailers and producers alike) poses a high risk and a strategy which has to be thought through carefully. The incorrect choice of closure could alienate consumers with dire consequences. There are market segments more receptive to change but only a carefully managed transition will be successful. The bulk of the report analysed the perceptions of closures across different demographic, behavioural and attitudinal segments.

## ◆ AUSTRALIAN WINE RESEARCH INSTITUTE

Synopsis of report downloaded in printed format (and not reworded) from [www.awri.com.au](http://www.awri.com.au)

The long-awaited, long-term (20-month) Australian Wine Research Institute 41-page report of an ongoing 10-year study into the behaviour of natural corks and alternative closures on a Clare Valley Semillon has finally been published. Unlike other studies which have, in many cases, come in for criticism for the funding, procedure and/or lack of impartiality, the AWRI report is scrupulously even-handed. One criticism that might, however, be made of it is that, while the alternative closures are all branded, no information is given about the producers of the two natural corks in the study. Some cork manufacturers make higher quality corks than others and it is thought by some to be unfair to treat all natural corks as though they were equally good or bad. However, according to Richard Gibson, Quality Controller at Southcorp, who was involved in the research, "In our experience, there is no such thing as a good cork manufacturer; there are just good batches."

The research was not, in any case, focused on natural corks, and when it began, some natural corks were in fact rejected because of evidence of taint. In other words, if they had been included, the figure of bottles with natural corks that were found to be TCA-tainted would have been higher than the four out of 14 that were reported.

Another possible failing concerns the way the screw cap bottles in the test were arguably over-filled (they were certainly fuller than if they had been prepared for sale) which may have affected the way their contents tasted. Given the steady evolution in the manufacture of synthetic corks and the claims that are being made for new techniques of natural cork production and treatment, the long-term performance of the closures may be of only academic/historic interest. These - relatively trivial - criticisms aside, the study has already revealed several important facts.

a) A variation in the capacity of various closures to prevent a loss of SO<sub>2</sub> (the antiseptic used to protect wine from bacteria and oxidation). The greater the loss, the faster the wine will age. The most effective closure in these terms is, predictably, given their history, the ROTE (Stelvin-style) screw cap. The Sabaté Altec and Amorim Twintop both performed well, as - to a lesser extent - did the natural corks and synthetics from Aegis, Auscork, Integra, NormaKork, Nukorc and Supremecorq. Ecorc and Tage were a little less successful but Betacorque was a failure which allowed large losses of SO<sub>2</sub>. Note: Since the beginning of this study, Supremecorq has launched a new version of its closure which is supposed to hold SO<sub>2</sub> better.

b) All of the Altec (agglomerate cork-and-glue) closures in the study tainted the wine with TCA (and/or with the aroma of the glue used in their production. Interestingly the report makes no reference to glue-taint, despite frequent references to it by critics and by correspondents to this site). Note: Altec is now launching a new version of its closures which are claimed to be nearly 100% taint-free.

c) The screw cap wines had a rubbery taint. Given the fact that there is no history of this problem in commercial screw cap releases, it is believed that it may have been a sulphur-related, reduction aroma caused here by over-filling the bottles.

d) Four of the 14 natural cork wines were tainted by TCA.

e) None of the synthetic corks was found to give a 'plastic' taint to wine, despite occasional previous references by critics to this being a problem.

f) The stoppers varied in the effort required to remove them, but the synthetics were generally tougher to extract and replace than the natural corks.

◆ AMORIM CORK AMERICA

([www.corkfacts.com/november2002](http://www.corkfacts.com/november2002))

A random selection of 200 winemakers was used to question closure preferences as well as taint percentages in wine. Conducted during May and June 2002 by an independent researcher, the findings were that 72% of the winemakers preferred natural cork as a closure; 14% synthetics and 11% screw caps. The survey also found that wine taint is not as prevalent as often thought. Respondents reported less taint in their own wine 0-1% than the perceived national average of between 3-5%.

◆ FRESNO STATE UNIVERSITY

([www.vwm-online.com/magazine/archive/2003/vol29](http://www.vwm-online.com/magazine/archive/2003/vol29))

In 2001, a study was conducted on Sauvignon Blanc of four commercial closures. Two closures were synthetic, one a top end natural cork and one was a technical cork. Six hundred bottles were bottled with each closure and aged for one year, neck down. The first sample was evaluated 50 days post bottling. Total sulphur dioxide levels dropped steeply in the first four months, although the cork stoppers had levels close to each other whilst there was a huge difference between the two synthetics. The value of natural cork as a closure was thus re-enforced, due to its ability to retain the anti-oxidant and preservative values of sulphur dioxide.

◆ APCOR

([www.corkmasters.com/pressrelease\\_march2002](http://www.corkmasters.com/pressrelease_march2002))

A survey was undertaken on behalf of the Portuguese Cork Producers by Moulton Hall (16-31 January 2002), which highlighted the significance of the closure type in wine purchasing decisions. As high as 75% of the sampled drinkers, expressed a preference for natural cork. These drinkers were sampled in Australia, America and the United Kingdom. Natural cork was seen as a quality indication in 69% of wine drinkers, plastic stoppers were viewed as having cheap connotations, possibly denoting wines of lower quality. (7)

The key findings were:

1. Real cork was preferred by 75% of wine drinkers surveyed
2. 73% believed that cork was the perfect fit for wine stoppering
3. 69% viewed cork as a quality indicator
4. 57% wanted information on stoppers in the wine they are buying
5. 52% would be disappointed if plastic was the replacement
6. 26% rated closure type as being more important than origin or price
7. 21% believed their off bottles were due to cork problems
8. 6 out of 10, viewed plastic stoppers as being cheap

◆ UNITED KINGDOM WINE AND SPIRIT ASSOCIATION

([www.corkfacts.com/november2002\\_no13](http://www.corkfacts.com/november2002_no13))

This controversial survey was commissioned by the Wine and Spirit Association in 2002 and examined almost 14 000 wines. The samples were mainly from France, Italy, Spain and Australia. A sharp decline in the incidence of mustiness in the 2001 vintage and non-vintage wines – compared with wines bottled in earlier years was noted. The conclusion was that mustiness affected between 0.7 – 2.1% of the wines sampled. The author of the survey, Martin Hall – director of food science at Campden and Chorleywood Food Research Association (CCFRA) – suggested that the lower incidence might have been because of the real reduction in affected corks. This being due to the major investment made by producers to modernise and to implement more quality control measures. Another possibility was that TCA does take time to migrate from the cork to the wine – apparently peaking between 12 and 14 months after bottling.

The survey methodology has been criticised due to the opening of the bottles for initial testing and then the time gap until subsequent verifying. This was over several days and as TCA is able to be re-adsorbed back into the cork, oxidation can mask its presence. The WSA believed the criticism not to be fully justified, pointing out that had all of the samples initially assessed as being musty due to TCA, then the incidence would rise to 2.1% and if all faulty samples (oxidised included) were also musty, the defect incidence would be 3.4% at most.

◆ QUERCUS

([www.corkqc.com/tcaquercus.htm](http://www.corkqc.com/tcaquercus.htm))

One of the studies undertaken in 1993, simply titled ‘Quercus’ combined the efforts of nine laboratories in six countries. This detailed study was a co-operation between the European Cork Industry Federation (CELIEGE) and the European Economic Community. The objective was to identify the sources of so called ‘off flavours’ associated with cork stoppers.

Whilst TCA ( 2,4,6-trichloroanisole) was the most prominent compound found to be the cause of an off flavour or mustiness, numerous other compounds were also examined. It was responsible for 70% of the bottles analysed which were regarded as off. TCA was however, again, pointed out as being linked to off flavours in other food products.

As TCA was so prevalent, each individual step of the cork production process was examined to track the formation of the compound. A protocol for the recommended practices by producers was the result of this examination. Storage issues were also highlighted as there was strong evidence of TCA being easily transmitted to corks from highly contaminated environments.

The single greatest correlation for TCA in finished corks was found to be the relative level in the original raw bark, and indeed even greater in bark closer to the ground. It was also concluded that chlorine based washes for finished corks resulted in a higher level of undesirable chlorophenols. These are a proven source of TCA as chlorophenols are metabolised by certain fungi. Chemicals containing chlorine have also been banned from fields around cork trees due to the role that chlorine plays in TCA's formation.

## **9. SUMMARY**

The closure issue for the wine industry should be focussed on whether or not the move from cork to alternatives is indeed market driven, or whether it is production driven. There is clearly no such thing as the perfect closure. There are however sales and marketing concerns with the alternatives where as the most forceful argument for natural cork remains its wide consumer appeal and the connotations of wines having been bottled with it, being a quality product. But the research costs are high in the quest of producing TCA free products, and technically there is no one definition of the perfect closure. Closures ought to be selected for their suitability to the contents in the bottle.

The natural cork camp has to regain lost market share, regain the trust and confidence lost in the 'real thing' due to quality issues.

Natural cork is quintessential to the heritage of the wine industry, it supports a nation, and is indeed its best ambassador. The forests are a unique ecological feature in Portugal's landscape and there is enough scientific evidence to validate this. Romantic and sentimental reasons aside, the very real susceptibility to contamination by TCA will remain the proverbial sword of Damocles hanging over the entire cork producing industry.

Sophisticated analytical techniques have made it possible for TCA to be recognised as a tangible problem and certain measures have been taken over the last decade to reduce and restrict the incidence and intensity. Pursuing this problem to a vanishing point makes it an increasingly sensitive issue – enhancing rather than reducing winemaker's concerns.

## CHAPTER 2

### SYNTHETIC CLOSURES

#### 1. CHAPTER INTRODUCTION

Technology and entrepreneurial spirit tackled the issue of developing alternative closures. Ones which would mirror the aesthetics of the natural, provide a hermetically sealed closure and most importantly, be free of taint and not support a sub-strata for any microbiological contamination. The drive was spurred on by the higher taint incidences which winemakers were starting to report, culminating in local and international wine producers suing various cork manufacturers for supplying substandard material. Subjective estimates are that the taint problems were identified over 25 years ago and that the cork producers failed to react until their market share was cut into. The manufacturers of synthetic closures estimate that they have around 10% of the wine closure market – and that it is growing in their favour.

Essentially plastic synthetic closures are manufactured using man made materials – the composition of which is akin to state secrets – but are created without the fine pores which the natural cork has. The elimination of these pores which can harbour bacteria is what makes these closures so attractive. The material from which all synthetic closures are manufactured is either medical or food grade plastic. They are guaranteed not to be the source of any microbiological taint. Their design also satisfies the traditional wine drinker's need to extract a closure using a corkscrew.

But these closures too have been shrouded with a degree of uncertainty and a somewhat sceptical past. The producers of synthetic closures also had to overcome product limitations and re-engineer and attend to specific aspects of production. They too have had their fair share of litigation and unhappy clients. But as this closure is made through a controlled process and is monitored every step of the way, the assurances and guarantees which suppliers such as SupremeCorq and nomacorc are able to give, unquestionably outweigh those of the natural cork producers. The sales brochures from both these suppliers make emotive statements as to the dreams and reputations of wineries and indeed their family heritages being at stake when wine bottles are sealed - all these concerns are reassured as being laid to rest should the wine producer select synthetic closures.

## 2. ADVANTAGES AND DISADVANTAGES

### ◆ THE PROS

The producers of synthetic closures refer to the benefit of their closure being a neutral product that does not add any flavours nor ‘scalp’ from the wine. Synthetics ensure that the wine seal will be consistent from bottle to bottle. And as opposed to natural cork bark, they are praised as they do not break, do not crumble, do not leak and certainly do not allow for any microbial growth and thus no TCA. They enable easier shipping and storage as bottles can be transported upright. Their behaviour in a bottle is predictable.

CEO of SupremeCorq, Robert Anderson reinforces the fact that synthetics still preserve the ritual of cork pulling. The fact that they ‘pop’ when pulled is rated as an advantage over screw caps. This makes for synthetic closures being more readily accepted by consumers.

There is sufficient producer survey data to reinforce the synthetics producers view point that their product is a significant development in the beverage industry. This is furthered by industry experts anecdotally noting that 90 % of wine is consumed within a year of purchase, and often within 24 hours of purchase. As such, those wine producers who are using synthetic closures are doing so in wines designed for early drinking and with an expected short term shelf life, such as Adelberg from Simonsig, Vin de Florence from Vergelegen and the Simons range from Simonsvlei.

There is unanimous agreement amongst winemakers that technically, synthetic closures are the logical ones to use. They are deemed to be the most advantageous closure for wines to be consumed within a year or two. They provide a closure that is uniform, does not taint and is dependable. (10)

The most notable exception to the short term proponents is St Francis Winery in Sonoma, California. Winemaker Tom Mackey first bottled his 1989 Merlot under synthetic closures. According to Paul van Dooren (GM SupremeCorq South Africa) the wines subsequent to this bottling are showing very well and are used to reinforce the advantages of synthetic closures

The most distinctive advantageous feature which a synthetic has over a natural cork is how it behaves under adverse conditions. The synthetic does not permit oxygen to enter the headspace under any temperature variances. Natural cork will inhale air to replace volume in the headspace after heating and cooling, whereas the synthetic is merely sucked back into the bottleneck when the wine contracts. Not unlike natural cork producers, there are quality/cost issues to be addressed with the synthetic producers as well. The harder synthetics are generally the cheaper ones, as well as being the ones which are likely to permit wine to drip through the corkscrew opening if the bottle is laid on its side. ([www.enologyinternational.com/cork](http://www.enologyinternational.com/cork))



## ◆ THE CONS

The critical disadvantage always quoted in discussion as to synthetic closures, is their extraction. Not surprisingly, consumers who first experienced these problems several years ago, remain daunted at the prospect of trying again. As no real advertising is targeted by the producers to consumers, how are they to know that the product has been improved upon and ought to be re-tried. Another concern which was brought to the synthetic producers' attention was the inability to reinsert the closure. After the initial guffawing and joking as to this being a complaint.....improvements have been made but the producers do recommend that the closure be re-inserted promptly after extraction.

One of the most significant of the synthetic closures shortcomings, is the inability to retain sulphur dioxide levels. As such the winemaker has to increase levels quite considerably at the point of bottling. For inexplicable reasons there is no understanding as to what causes the sulphur levels to fall so dramatically. (10)

This problem was again displayed in the AWRI results where the best levels were maintained under screw caps. As such, any winemaker contemplating the use of synthetics for bottle ageing wines is advised to adjust the style of winemaking to compensate for the closure. SupremeCorq certainly advocate the need for trialling any wine under the synthetic closure before going ahead with a full bottling. Various components of certain wines may react unfavourably under the synthetic.

It is the long term testing that is eagerly awaited as the main question pertaining to these closures, remains that of age ability and how the closure will perform as a test of time.

### 3. PRODUCTION OF SYNTHETIC CLOSURES

The South African market is the playing field primarily of four synthetic closure producers – SupremeCorq, nomacorq, Integra and Classic Closures. The author has elected to discuss and compare the first two producers due to the market share that they control, locally and internationally, and because they both use very different production techniques.

#### ◆ SUPREMECORQ

SupremeCorq's closures are made from a high grade thermoplastic elastomer. This material is used in biomedical equipment such as syringes, medical tubing and heart valves. Because it is made from an elastomer, the corq has elastic type properties which allow it to expand, contract and rebound. To produce food contact grade quality plastic, a variety of basic compounds for example carbon, hydrogen, oxygen and nitrogen are extracted from natural products such as petroleum, coal and natural gas. (10)

The various component ingredients are delivered to the production facility in Kent, Washington – United States. The product is then manufactured within this factory. All of the individual suppliers to SupremeCorq and their manufacturing procedures are ISO 9001:2000 compliant.

The product has also been awarded the American Baking Institute certification due to the closure being used in the food industry. Each corq is moulded as such, individually injected– as opposed to nomacore’s extrusion production. Injection moulding has benefits in that each unit is individually manufactured to ensure consistency. Frayed ends and loose particles are eliminated and shorter, cost effective production runs are possible.

The outer skin completely seals the enclosure, protecting internal cell structure and preventing wine absorption. This skin (the components of which are clandestine) also allows the closure to conform more readily to the surface of the bottle bore, so ensuring a proper seal. A food grade silicone is used to lubricate the corq; a specific amount being mechanically measured and applied during the finishing process. The amounts are checked through extraction force measurements.

Extraction tests are conducted on an automated industry standard extraction unit. The ability to maintain a seal whilst still allowing the closure to be removed from the bottle is critical. The standard is set at 22-38 kilograms or 216-373 Newtons. These tests are performed on every order produced. Much re-engineering has been undertaken at this phase of manufacture as it was the legacy of poor extraction which hampered the wider acceptance of the synthetic closure. The corq can become marginally more difficult to extract after the bottle has been chilled – a “waiters’ friend” type of corkscrew is the recommended opener.

Every half an hour of a production run sees a batch of corqs being quality tested for a variety of properties – density, length, weight, diameter, coating consistency and insertion and extraction force. The use of superior base materials enables the elastomeric properties of the product and facilitates the printing adhesion characteristics. Each corq is furthermore checked for structural integrity and oxygen barrier ability.

The closures are available in three different types and sizes: 45mm, 38mm and the T-tops. (T-tops are a pull closure used extensively in the fortified wine and spirits industries.) The Preserva range is recommended for wines which are to be aged longer in bottle. Through innovative developments, such as infusing the Preserva range with sulphur dioxide, SupremeCorq has been able to improve upon the current product to eliminate undesirable performance characteristics and give winemakers, and ultimately consumers, a better product, according to Paul van Dooren – GM SupremeCorq SA.

The corqs are sealed in carbon dioxide dosed storage bags and exported from America to the international branches. The thousand corqs per bag have a best before date of 8 months from manufacture. Should there be any delays in shipping this does affect the batch arriving in any given country. As was recently the case in South Africa, the container was merely re-routed to China for recycling. The greatest shipping problem faced is the corqs drying out because of the silicone coating.

SupremeCorq claim that more than 1000 wineries in over 30 countries currently use their product.([www.supremecorque.com/faq](http://www.supremecorque.com/faq)) The preferred reasons are for the near perfect seal which is formed, the virtual elimination of taint, no leakage problems, and the storage of bottles upright and that synthetics can be used on existing bottling lines. Corqs are available in a standard range of highly fashionable colours as well as being made in any winery specific colour. Currently in South Africa they are a more affordable option as with a favourable exchange rate, the least expensive cos 55cents. Mr van Dooren was of the opinion that there had been a certain share of the market lost to screw caps but that there will be a gradual move back to synthetics. The primary reason being that the extraction issue has been adequately addressed and that consumer surveys are showing synthetics to be more acceptable than screw caps.

SupremeCorq are to release an ‘evolution’ of the synthetic closure in January 2004. Whilst still being under lock and key, the most information I was able to obtain was that the newer product would be more uniform and compact (“there would be more material on the inside”) as greater regularity of the internal cell bubbles aids in the retention of sulphur dioxide. (10)

#### ◆ NOMACORC

These synthetic corks are created using the technology and experience developed by Nomacorc S.A. in Belgium and Nomaco Inc in the United States of America. The two companies specialise in the extrusion of engineered plastics and manufacture for very diverse markets such as automotive packaging to toys. The worldwide demand for alternative closures in the wine industry led to creation of nomacorc. (11)

As is to be expected with products in a highly competitive environment, the technical specifics of production are quite clandestine. There is very little disclosure as to the exact materials which comprise the synthetic closure. What was imparted to me in an interview with Ken Bode (MCG Technical Director) was that nomacorc is an extruded product with a foam core, created from polyethylene. The composition of materials is patented and the components of the outer skin of the cork are akin to state secrets. The analogy of extrusion drawn for me, was that of producing sausages. All the various materials mixed together, worked into the skin, pulled through a machine and then cut.

These synthetics are manufactured with an innovative, proprietary extrusion process. This fully automatic and continuous process method melts polymer pellets then forwards the mix with a screw mechanism, until the mixture exits the extruder through a die - which creates the desired product shape .

To the core extrusion is added the co-extrusion of proprietary polymer which forms the 'skin'. This continuous process ensures high consistency in terms of density, cell structure and dimensional control. With consistent density and a uniform cell structure, protection of the wine is greatly enhanced. A smaller and more closed cell structure creates a better barrier against oxygen permeation.

Fundamentally the benefits of the synthetics are the same across the board, varying slightly per producer because of the differences in the production process. Nomacorc's sales brochure attests to the preservation of the wine's quality as there is no taint, no flavour modifications due to the closure and no microbiological contamination. The document also states that the synthetic is compatible with bottling lines, no leaks and upright storage of the bottles are benefits, prices are stable due to the virtually unlimited supply of raw materials, a longer shelf life for the unused closures as well as less testing required to be done on the incoming product. They also comment on respecting the tradition of the wine ceremony as there is a similar appearance to natural cork, the synthetic can be extracted using all standard corkscrews with consistent extraction forces of between 30 and 37kg.

Synthetic closures are not a total oxygen barrier and as such nomacorc boast a controlled oxygen transfer with their product. Essentially what this feature enables is a more consistent ingress of oxygen – 'x' percentage over a certain time period. The advantage over natural cork is that this ingress is specific and constant whereas there is no such measure with natural.

#### **4. CONSUMER ISSUES**

Synthetic closures are criticised for being an environmental danger and indeed several organisations opposed to more tonnes of plastic being dumped into the environment, often cite the recycling issues, extolling the virtues of biodegradable natural cork. To counter this, SupremeCorq has joined with Oddbins in the United Kingdom in a recycling initiative which sees the synthetic closures being collected in stores and then consolidated; to be shipped off to China. There is only one plant capable of breaking down the polymer efficiently and this is situated in China. Once broken down the polymers are recycled into end products ranging from sneaker and shoe soles to plant containers. To date, this practise is not undertaken in South Africa.

Nomacorc state that their product is made in accordance with FDA approved materials and in a Good Manufacturing Plant. No plastic is thrown away and all surplus material and waste is reused to make other recycled products. The closure itself is 100% recyclable and does not contaminate the soil or ground water when disposed of in landfills.

At the time of writing the most definitive research at hand which was being extrapolated across the wine drinking world, was 'Closures – the consumer view' undertaken by Wine Intelligence. Acceptance of synthetics outstripped that of screw caps but percentages reflected are generally far behind in the preference for cork. The synthetics did however receive percentile ratings higher than screw caps. They were viewed as positive, reliable and modern. They rated as 'neutral' and not affecting a purchase decision by 70.6% of respondents and the quality of wine perceived by consumers as being sealed with a synthetic rated highly - as opposed to the screw cap. (The complete document is attached as an appendix)

## 5. STORAGE AND BOTTLING GUIDELINES

SupremeCorq recommend an extensive testing period so as to ensure that the desired wine results are obtained, if their synthetics are to be used. Due to the variability of global winemaking and bottling techniques, winemakers need to make adjustments based on wine, equipment, storage and bottling conditions. (10)

### 1) Storage of corqs

- a) To be kept inside sealed packaging until intended time of use
- b) Avoid storage in areas of extreme temperature changes
- c) To be kept in a clean, dry area separate from any cork bark products
- d) To be used within 8 months of manufacturing date
- e) After bottling, remaining corqs to be resealed in plastic bags

### 2) Preparation for bottling

- a) To minimise risk of premature oxidation, dissolved oxygen in the wine in bulk should be less than 1 part per million
- b) All tree bark cork residue to be removed from bottling area
- c) All corker points of contact to be cleaned and sterilised prior to use of corqs
- d) Corking jaws to be free of damaged edges which might cut or crease closure
- e) The cork plunger to be centred and straight
- f) The corker jaw compression diameter to be set between 15.5mm and 16mm

### 3) Temperature of wine

- a) Wine temperature should range between 16-21°C during bottling. If bottling at lower than 16°C, attention must be paid to fill heights to offset the wine expansion caused by a temperature increase
- b) After bottling, wine should remain as close to bottling temperature for a minimum of 48 hours to allow the corq to seat in the bottle
- c) Bottles can be stored upright or immediately inverted during this period

### 4) Vacuum/head space pressure

- a) Head space pressure is a primary consideration due to the sealing qualities of the product. A vacuum corking machine is recommended with the actual head space pressure as close to neutral as possible
- b) The corker vacuum to be accurately calibrated and in good working order
- c) Headspace pressure checks to be made on a regular basis during bottling

- 5) Carbon dioxide and bottle pressure and Sulphur Dioxide levels
  - a) Levels of carbon dioxide exceeding 2500 ppm are not recommended (it would be extremely rare for still wines to have levels higher than this)
  - b) Residual sugar in conjunction with pressure complicate the ability of the closure to produce an immediate seal – a 24 hour observation period is recommended
  - c) Sulphur dioxide levels will vary with type of wine, storage conditions, additives and winemaker preferences – a table of suggested levels is available from the supplier. Wineries are encouraged to monitor the levels
  
- 6) Bottle run monitoring and Shipping procedures
  - a) All runs must be monitored closely and relevant data recorded and maintained e.g. head space pressure, temperature, chemical analysis, production date, bottle type and batch number, cork lot numbers
  - b) Wines to be shipped and stored at consistent temperatures and not exposed to rapid fluctuations or high temperatures over an extended period of time

## **6. THE SOUTH AFRICAN PERSPECTIVE**

It is certainly not a surprise that there are numerous wineries in South Africa who use synthetic closures. A significant number of these wineries are volume driven producers who also export a considerable number of cases, out of South Africa., for example Vredendal Winery, Kumala and Swartland Wines.

During brief discussions with several diverse wine retailers in South Africa, a general theme which ran through was that of synthetic closures now viewed by consumers to be the closure in the lower priced and early drinking styles of wine. Extraction and re-insertion problems were quoted by the retailers with seemingly little understanding by them as to the product's technological improvements. (Of concern was also very little understanding as to the different types of cork stoppers – i.e. whole and technical – several of them had no knowledge in this regard). It appeared to be only those retailers who bought for larger chain stores or who managed their own boutique wine stores, who ensured that they “were up to speed” as to developments. There were several references as to “the early days” when consumers refused to purchase a bottles stoppered by plastic, re-purchasing was certainly not entertained if they felt they had been caught unaware. These days, synthetics are seemingly accepted, they are in numerous product lines on the shelf and if that particular wine is sought by the consumer, then it is merely purchased as alternative options might not be available, or indeed even a consideration.

Kumala Wines (owned by Western Wines) has gained an enviable position as being the largest selling South African brand in the United Kingdom. Kumala was introduced onto the South African market in September 2003. Whilst the entire has not been launched, only the premium Journeys End and Reserve ranges, the closures to be found with the latter are synthetics.

Kumala Wines were among the first major international brand to use synthetic closures – reinforcing their positioning as being one of the world’s most innovative and dynamic brands. The move to synthetic closures was prompted by the international wine buyers. (12)

Simonsig Family Vineyards use synthetic closures for bottling their range of Malan Family Vintners wines. In speaking with Johan Malan, he advocates the use of these in wines which do have a quick sell through rate and are not intended for long term cellaring. Costing around 70 cents per item (depending on quantity) these closures provide for safety of mind in that they do not present any of the ‘traditional’ problems and are readily accepted by the market. His preference is for nomacorc and to date has experienced no off flavours or returns from customers. He does purchase in across the range of closures for different purposes – with the premium quality natural corks sealing Simonsig’s flagship wines. Mr Malan was also of the opinion that if over supply ever was to become an issue as synthetic closures become more appealing to a larger proportion of producers in the lower to mid end ranges, then quality issues may come into play (not unlike the cork producers). He also expressed no immediate desire to bottle under screw cap; quoting the recently released Wine Intelligence survey in that demographics would have to come into play in respect of the selection of cork or screw cap. (13)

## **7. SUMMARY**

The main critics of the Portuguese cork industry as well as those who have urged reform are viewed as being the ‘upstart New World winemakers’. In reality the technical investigations have been led by New World wine producers and several solutions have been proposed by them. Not surprising when noting how New World producers have forged ahead with clean and fresh styles of wine. And how damaging the effects of a musty off flavour can be on these styles of wine whose primary appeal is their upfront fruitiness.

However there is consensus from both wine and closure producers that the industry can support different closures for different products. The synthetic producers are under no delusions and there are no plans for world domination – instead, supplying a product for the short term closure of wines designed to be consumed early. And with continuous research and development to evolve the current offerings to be better suited to a wider range of wine as well as age worthy reds.

The synthetics certainly do fit the consumer’s requirements of a closure which looks and sounds more like natural cork, more so than what the screw caps do. Most winemakers and marketers however acknowledge a progression to screw caps being the preferable route, rather than moving from natural to plastic. The controversial aspects of this closure again highlight the need for trade and public education as misconceptions exist and unless they are cleared up, misinformation could well be the death knell for alternative closures.

## CHAPTER 3

### SCREW CAPS

#### 1. CHAPTER INTRODUCTION

The closure issue is highlighted most profoundly by the debate which pits defenders of tradition against practically minded dispassionate people who view the selection of closure in the clearest light – and the choice of screw caps provides an arena in which to do it. Screw cap refers to any metal cap which is capped over a bottle top; the term Stelvin is used nowadays interchangeably but should specifically refer to the patented closure of Pechiney, France and the term Savin cap to refer to the product of MCG Industries in South Africa.

Dan Rylands of Barnsley in the United Kingdom patented the screw cap on August 10<sup>th</sup> 1889. Searches for references as to the first time use of screw caps for wine, yielded no information. However, the Whiskey Bottle website details ‘the replaceable cork and self opening bottle’ as being part of the slogan of Teacher’s Highland Cream in the early 1900’s. A screw cap was introduced in 1926 by White Horse Distillers, an innovation which doubled sales in six months. Until 1913 whiskey bottles were sealed with cork.

Over the last half a century screw caps have been used extensively in the wine industry. The first seals were found to be unsatisfactory and it was not until the introduction of the Stelvin closure - developed in the late 1950’s by La Bouchage Mecanique, a registered trademark of French manufacturer Pea-Pechiney - that the seal came to be recognised as a quality product. The long skirted Stelvin closure was created specifically for wine bottles and was developed from the Stelcap, which used to have cork liner.

At the time of writing, there were numerous internet surveys which were being undertaken to disprove the Wine Intelligence closure survey which proclaimed that ‘cork is king’. (This survey has already been referred to in the chapter on natural cork; the entire document is copied as an appendix)

A survey was commissioned by Villa Maria in New Zealand and their conclusion as to consumers’ views on screw caps was vastly different to Wine Intelligence’s findings. Tickbox.net undertook the research in early September 2003 and yielded results which showed a considerable acceptance of the closure by 2702 respondents, 64.4% of them had bought screw capped wine or were prepared to do so. (Villa Maria had decided in 2002 to close all their production with screw caps).

Producers of alternative closures are each trying to prove that their product is being accepted by various niche markets and so could be the rightful successor to natural cork. There is undoubted acceptance of the closure within specific target markets, but the question to be posed is whether the move towards screw caps is a production or marketing driven issue. Is it truly the consumer who is driving the screw cap revolution or is it the wine makers and closure producers or indeed the retailers who are motivating it?



## 2. A BRAVE NEW CLOSURE

The metal screw cap with the appropriate liner, is a barrier which air can not diffuse through. (11) Therefore ageing reactions which are dependant on oxygen will not occur. Vernon Singleton (UC Davis Professor Emeritus) a leading international authority on wine ageing, states that the chemical reactions responsible for bottle ageing are not oxygen dependant, implying that the alternative closures will not interfere with bottle ageing. His opinion is that bottle ageing does not occur unless there is considerable protection from oxygen. (14)

The concept of the passage of air and micro-oxygenation that occurs is one which certainly has two very distinctive camps of winemakers. It is possibly this conflict which could be the brake on a wider acceptance of the screw cap. The traditionalists, both consumer and winemaker, with fervent beliefs that bottle ageing is only possible with a cork, are pitted against the modernists, seeking a closure which preserves the wine and allows the numerous and varied chemical reactions to occur in the absence of air. (The latter mentioned winemakers dismiss the notion that miniscule amounts of oxygen move through the cork into the wine to enable bottle maturation).

The most extreme measure taken to date by any wine producer was that of Napa Valley's Plumpjack who bottled 300 cases (half) of their reserve Cabernet Sauvignon 1997 under a screw cap – the wine sold for US \$ 135 per bottle. This move received a great deal of attention, not only in view of its statement on closures for age-worthy reds, but also to illustrate the extent that producers will go to, to register their displeasure towards natural cork. Plumpjack, not unlike several South African producers, however have not totally abandoned cork altogether.

Vergelegen sent a very strong message into the local wine trade when 500 cases of the 2002 Sauvignon Blanc were bottled with a Stelvin closure. Andre van Rensburg is quite vehement on the topic of the unacceptable level of poor quality corks. The winery had to tolerate numerous complaints pertaining to the high incidence of TCA infected corks in the bottles of the 1999 Vergelegen Red. These culminated in the withdrawing of the product from the market and the search for alternatives was embarked upon.

Any producer undertaking such a dramatic step has to think about the marketing ramifications as screw caps are perceived by many consumers as cheapening a brand. A considerable concern expressed by Eddie Turner (Group Marketing Manager – Amfarms) especially in light of the recently published Wine Intelligence survey which clearly revealed the consumer view of screw caps being the type of closure used on inferior beverage products. An opinion also expressed by Andries Burger, winemaker at Paul Cluver Estate, that only when the consumer market starts to demand the closure, would they consider using it. Consumer perceptions and brand building are integral in the Estate's long term planning - adoption of an alternative would only ever be undertaken after very careful and no doubt serious deliberation; as well as definitive marketing research.

### 3. TECHNICAL SPECIFICATIONS

The outer, visible layer of the screw cap is made from an aluminium based alloy. Inside of the twist top is a multi layered liner. The modern screw cap differs from the original Stelcap only in the wadding material. Essentially there are coverings over the expanded polyethylene liner – a round disc shaped item which is punched into the closure during the manufacturing process. This disc lends the elastic resilience to maintain the liner's compression. It is not the aluminium cap which provides the much sought after impermeable gas barrier but rather a film of tin foil less than a 15<sup>th</sup> of a millimetre thick. This is separated from the wine by a very thin film of inert polyvinyl denachloride – PVDC. PVDC is a solid plastic polymer. Solid, in that it is not a gas filled puffed polymer. It is an un-pigmented pre-shrunk film which is laminated to the tin of the capsule. Older and earlier liners had agglomerate cork on the backing; the greatest problem experienced with these early attempts was the non-recovery of the cork after pressure had been applied during capping. (11)

During the capping process the central polyethylene section of the liner is compressed over the end of the bottle and so forms the seal. Of importance is the total compatibility of the glass bottle and the screw cap to guarantee perfect capping and sealing. During the bottling process, the cap is dropped over the bottle top and the seal is formed by the capper. Two sets of rollers effectively create the thread and PP groove as is seen on the finished product. The PP groove is the horizontal groove which is rolled into the closure during the application by the 'skirt rollers', thus locking the lower portion of the closure onto the bottle. The lower section or 'skirt' of the closure stays on the neck of the bottle whilst the threaded section comes away in your hand. These rollers are set to specifications and profiled to be compatible with the finish of the bottle. Pressure is exerted from above the capper to enable the formation of the 'reform' which folds the liner around the sealing shoulder of the glass finish.

A concern to the producers wishing to follow the screw cap route, is the prohibitive cost of bottles and packaging. The cost of any glass bottle increases incrementally due to factors such as weight, style and colour of glass. The bottle lip has to be perfectly moulded to facilitate the screw cap as any deviation will result in the ineffective and improper sealing. New bottling lines have to be implemented. At an approximate cost of R 200 000 this type of commitment has to be taken seriously. Careful selection of mobile bottlers is a must. Application errors could compromise the efficacy of the seal as the film in the liners' inner part of the cap can be damaged. Packaging and handling have to be closely monitored as well.

Until a year ago, there were no locally produced bottles which were suited to the Savin closure and bottles had to be imported from Saver Glass in France. Nowadays, Consol Speciality Glass and Nampak manufacture bottles in South Africa. However as the demand for screw caps increases, this will enable the greater selection of bottles as the local manufacturers will be obliged to provide a wider range.

Not only does careful attention have to be paid to the fill heights of the bottles, but as the bottling lines for cap closures do not allow for the pulling of a vacuum, the headspace is normally purged with an inert gas as selected by the winemaker, before capping. A fill height of 30mm at 20°C is recommended, albeit that these figures might well be altered depending on the bottle variations.

For bottling with an aluminium closure, it is recommended that the cap manufacturer is in contact with the bottle supplier so as to make necessary changes to the mould or finishes of the bottle. Ken Bode (MCG Technical Manager) stated that MCG certainly do work very closely with the bottle manufacturers to ensure that all the components are within the specification limits. Steve Bell ((MCG National Sales and Export Manger) succinctly stated that they are “the custodians of the bottle neck”.

The new generation of closures have a superior feature, that of ‘redraw’ or ‘reform’. The lack of this feature on older versions is what could have caused the wad to be lifted from the top surface of the glass, if the seal was dented. Modern capping blocks draw the aluminium outer very closely around the glass rim profile. Air gaps are thus removed which would have provided room for indentation and resulted in seal failure. This improvement makes the seal safe from external impacts, as well as increasing durability and sealing efficiency.

Pechiney, the French company which has the patent rights to Stelvin, claim that the most important part of their closure is indeed its lining, which features two layers. An elastic compressible material ensures an airtight seal and then there is the inert plastic film barrier. Stelvin guarantee their closure not to leak, that it will preserve aromas, meets food regulatory requirements, offers economy (combines cork and capsule functions) and is recyclable.

#### **4. INTERNATIONAL APPLICATIONS OF SCREW CAPS**

In the early 1960’s Yalumba (Australia) released a series of premium wines bottled with the Stelvin closure. According to their sales reports, consumers did not accept the wines at the time as it was only ‘cheap plonk’ which was viewed as being closed by metal caps. Retrospective tastings undertaken by Yalumba reveal that the wines are still in excellent condition. Back in the 1970’s Chateau Haut-Brion undertook tests over a ten year period - these initially showed that wines in screw cap bottles were no different to those under cork. The plastic film in the screw caps on the 1969 wine started hardening and breaking resulting in oxidation. The deterioration became so pronounced that the experiment was stopped. (14)

Professor Emile Peynaud went on record in the 1980's stating that screw caps are the perfect way to seal a bottle of wine. At the time of writing, the greatest proponent of a change to screw cap at retail level is Tesco – Britain's biggest supermarket group and largest wine retailer. Tesco sells well over 200 million bottles a year and began their campaign advocating screw caps when they calculated that 1 in 12 bottles was affected with TCA. They have gone from nothing under screw caps to more than 100 million such bottles, in 18 months – such is the scale and speed of their screw cap revolution. ([www.independent.co.uk/features/story\\_aug2003](http://www.independent.co.uk/features/story_aug2003))

There are various Australian and New Zealand producer trials under way, and the successful results which are released from the wineries present a compelling case for red wines under screw cap. As a greater number of red wines than ever before are appearing on shelves, an ideal opportunity is being provided for comparison. The rate of development of a capped wine is drastically reduced as is evidenced by the greater amounts of sulphur dioxide retained. These wines maintain the purity of the varietal fruit character better than cork in the opinion of Kumeu River's Michael Brajkovich (New Zealand) and Stephen Henschke of Henschke (Australia). Clare Valley winemaker, Andrew Mitchell points out that, "Old wines under screw cap are typically described as fresh. People interpret this as meaning 'not mature' but this is a different concept. These wines still have the full array of mature characters, but with life."

Only time and trial will resolve the question of long term sealing with absolute certainty. As a number of key issues are raised in respect of the role of cork and oxygen and long term maturation. Again, it is the Australians who lead the way with numerous examples of screw capped wines from a range of wine producers and whose long term cellaring have afforded the comparison options. There is hardly a negative word printed as to the how well the wines showed, tasted and held out – no taint and no oxidation. Dr Bryce Rankine, one of Australia's foremost wine research scientists is quoted as having said, "I myself have very little doubt that screw caps in red wines will take off in the same way as they have in white wines. Watch the show results. My guess is that the Stelvin closure results will be superior to those of cork." (14)

Other examples of the growing use of screw caps are:

◆ The Clare Valley Riesling Producers (Australia)

Riesling being a very aromatic and a delicately perfumed wine, is very susceptible to having its character drastically altered by the slightest concentration of cork taint. It was frustration with taint and the desire to produce a quality wine which led 15 of the premium producers of Riesling in the Clare Valley to make the biggest endorsement of all – they bottled their wines with Stelvin. A special bottle was commissioned in France for the producers and the launch slogan was 'Riesling with a twist'. To date, it has been a particularly successful promotion.

◆ Gaja

Super star Italian producer Angelo Gaja has bottled his collection of library wines under screw cap. These are wines intended for future tastings. Yet he has the reputation for using the world's longest, finest and most expensive corks for the wines which he sells.

◆ Penfolds (Australia)

Since the early 1980's Penfolds has been testing different closures on their mighty Cabernet/Shiraz blend, Penfolds Grange. Head Grange winemaker, Peter Gago, when interviewed online by Decanter.com ([www.decanter.com/nov2003](http://www.decanter.com/nov2003)) stated that the trials were provoking research as it was clear how little understanding there is of the chemical ageing of wine under the alternative closures. The wines were evolving more slowly but consistently and comprehensively. He viewed the wines under cork and screw cap as "being more or less identical – the differences being very subtle, such as ageing in a cold cellar and a very cold cellar". These are however trails pointing the way, as sulphur dioxide, aldehydes and volatile acidity levels are monitored.

In replying to why they have not taken the plunge and bottled all of their good wines under screw cap, Mr Gago replied, "Discerning consumers understand the benefits, but we can't take the risk. We don't know what screw caps will do after many decades. The polymer in the seal is said to be inert but this is only defined over a particular time frame. It may be inert for 10 years, but what about 20 or even 50? We just don't know how they will perform long term". (Penfolds offer re-corking clinics to check existing corks in bottles, often removing and resealing with a new cork. Could the same not for an option for the future with bottles being recapped - seemingly a simpler process and one which avoids the risk of taint).

◆ Randall Grahm

Flamboyant Grahm of Bonny Doon Vineyards in Santa Cruz, California fired a powerful message to the cork producers when he staged an elaborate funeral procession and wake through the streets of New York in November 2002. Jancis Robinson delivered an elegy to cork at the faux funeral, referring to its "utter darned ridiculousness as a 21<sup>st</sup> century stopper". Grahm subsequently bottled his 2002 wines under screw caps stating that "the screw cap is a superior closure". In a daring move Bonny Doon put screw caps on all 80 000 cases of their 'Ca del Solo Big House' red and white table wines. He was one of six leading American winemakers who abandoned cork that year.

## 5. THE SOUTH AFRICAN PERSPECTIVE

It was as early as the 1970's that screw cap closures were highly praised by Gunter Brözel after their seemingly faultless performance on the 250ml bottlings of wine for various airlines. MCG Industries in South Africa operated under an agreement with Pechiney for the production of the Stelvin closure locally. Upon expiration of the contract, MCG registered the Savin closure. The company has a remarkable history and background having seen the screw cap through various phases in the local market. Their involvement in capping spirit products paved the way and provided the learning curves.

Savin is the screw cap closure of choice for several South African wine producers yet MCG also boast an impressive list of international customers using the product. In a personal interview with Ken Bode (MCG Technical Manager) and Steve Bell (MCG National Sales and Export Manger) the opinions expressed all centred around the sealing abilities of their product to keep the wine taint free, aromas fresher and indeed the fruit component of a wine in a more pristine condition than what cork can offer. Whilst consumer resistance and the failure of screw caps to play a more meaningful role in the wine industry, is attributed by Mr Bell to a real lack of understanding on the part of the consumer – he is tackling the education issue head on. Expressing regret that the South African Screw cap Initiative has not been as successful as the Australian and New Zealand chapters, he is undertaking coverage of the closure in life style magazines – fully aware that it will be a producer driven effort as well as a winery effort to persuade the masses that the closure is neither cheap, nor nasty. The Australian market for screw cap closed wine is estimated at 15% and is plainly attributed to consumer education. Mr Bode also noted that it was primarily the wine producers who export to the UK market who first took the step to screw cap due to the requirements specified by the European wine buyers. In their opinion, the closure has a very real future in South Africa.

Mr Bell put a humorous twist on our discussion by quoting Bob Campbell (New Zealand wine critic and Master of Wine): “Just imagine the response, if the whole wine industry had been using screw tops for generations and some bright spark popped up to tell us there was this great new thing called cork. Of course, it means that about ten percent of wine will be tainted, there will be dulled fruit flavours, musty odour problems and variation in wines as they age. But hey, it makes a great sound when you pull it out of the bottle!”

- VERGELEGEN

In personal interviews with Eddie Turner and Andre van Rensburg, it was apparent that the phenomenal step Vergelegen had taken in bottling a percentage of the 2002 Sauvignon Blanc under screw cap was a decision which had numerous ramifications. (15) Mr Turner agreed with me when I put it forward that the reason the wine sold was in part due to the Vergelegen name as well as the short supply of Sauvignon Blanc in that year. Only 500 cases out of the 10 000 cases were screw capped, and 80% of that was exported. He was also of the opinion that the venture was “hardly successful” as certain retailers did not buy into the concept. Of graver concern was the already referred to and recently published Wine Intelligence survey which showed screw caps are being viewed in quite a negative light. The brand perception of Vergelegen is a particularly valuable commodity and not something which could be played around with.

Mr Turner also highlighted the danger of the United Kingdom based supermarket Tesco, enforcing screw caps as their preferred closure. (Tesco wine buyers are actively encouraging their suppliers to bottle with the closure). Quoting international statistics which break down the wine market, the fact that 50% of the worlds’ wine is sold at 3 Euros or less and with Tesco’s average selling price of £5, there is a very real danger of them promoting the image of screw caps and their association with cheaper wines. It is clearly Vergelegen’s goal to set trends in respect of their wines and not their packaging. Of interest will be the 1500 cases of 2003 Vergelegen Chardonnay which have been bottled under screw cap. This should be the acid test as the varietal has decreased in popularity which might well hamper the sell through rate. Going ahead meaningfully with screw caps was an avenue Mr Turner did not appear to be comfortable with.

Winemaker, Andre van Rensburg declared quite emphatically that he is not anti cork, he is merely being realistic in using alternative closures. He views the economic failure of cork as being an unacceptable issue in that it is the winery “which has to take the punch” when product is returned due to defective corks. He aims to ensure as taint free a cork coming into his winery by demanding that the batches are sent for laboratory analysis. At an approximate cost of R1 per cork the items are laboratory checked, not only for the irksome TCA content but a detailed six page report even comments on how much dust was on the cork. Cork producers failing to make the grade or having supplied infected material, are rapidly dealt a blow! (Mike Ratcliffe, GM of Warwick Estate, also insists on the laboratory analysis and sees this as part of the insurance policy to minimise the number of infected corks. Although in a discussion with him, he pointed out that in no way would he be dabbling with screw caps.)

Mr van Rensburg quoted an anecdotal figure of 95% of the consumer complaints that he has to tolerate as being cork issues, and not wine issues. He is adamant about the fact that he is not prepared to lose a client due to a defective cork, and if this means changing to alternatives, then so be it. Apart from the Vin de Florence which is under synthetic, and the small number of cases under screw cap, the Vergelegen range is bottled with whole natural cork stoppers which cost upwards of R8 per cork. Going ahead meaningfully with screw caps is an avenue Mr van Rensburg does appear to be comfortable with!

- SIMONSIG

Johan Malan (winemaker and owner) did not express any desire to bottle wines other than the 187ml Chenin Blanc and Adelberg under screw caps. Whilst indicating that these closures were due to the airline requirements, they were certainly not without their problems. The greatest being that of oxidation. The seal can be broken in any number of situations from technical applications through to incorrect storage and handling. When such incidents occur the winery is again held responsible for these now 'defective wines'. Due to the size of the Simonsig range and the considerable spread of price points, a cross section of closures from agglomerate champagne stoppers, through natural corks, synthetics and screw caps are used. (13)

- KUMKANI

Stellenbosch Vineyards elected to bottle their 2003 Kumkani Sauvignon Blanc under both cork and screw cap closures. Their rationale being that Kumkani is primarily an on-consumption product and thus they opted for a more cautious approach. According to Carol Maggs of Stellenbosch Vineyards "we service a number of restaurants/hotels with this product and there is still a lot of work to be done with changing the paradigms of the wine purists. Cork finish is still the 'preferred choice' for this channel".

Both closures were released at the same price point in a move to enable the consumer to experiment without price clouding the issue. A Shiraz/Cabernet 2002 is to be released under screw cap in the first quarter of 2004. Chief Winemaker Chris Kelly is responsible for the move to screw caps as he views the closure as being most effective for preserving the fresh fruit character of the wine styles they are creating, as well as eliminating the risk of taint incidence. He is of the opinion that consumers have become more accepting of screw caps and that as producers they have to explore any new developments which benefit the consumer.

- WESTERN WINES

It was pointed out by James Reid (Operations Director Western Wines) that the only reason a Kumala Reserve range was bottled under screw cap was upon the insistence of leading UK retailer, Tesco. This was undertaken in October 2003 and is a range set aside for Tesco. As the product has not been on the shelf for a great length of time, it was too early in Mr Reid's opinion to comment on the acceptance or resistance by consumers. The impact of the already referred to Wine Intelligence survey was again cited for its findings of the negative perceptions by consumers of screw caps. Mr Reid also expressed the concern echoed by many wine producers that wines bottled with screw caps and which are below the £5 price point in the UK market, are perceived as down market. He felt comfortable with the Reserve range being under screw cap as the wine sells above £5. In a further bid to overcome the price point issue as well as meet the retailers' demands for screw caps, Western Wines bottled a New Zealand Sauvignon Blanc for the UK market which slotted in at a £9 bracket. (12)



- FLAGSTONE

Bruce Jack took up the challenge of bottling selected wines across his phenomenally vast range, under screw cap in 2003. These are expensive wines, ones likely to be collected and cellared. Being a fore-runner and quite a trend setter on the local market, he has clearly made his point. Consumers can be reconditioned and the sound of the cap clicking as it breaks, can be just as delightful as the traditional pop of a cork. Except that there are no unpleasant taint surprises lurking once the bottle has been opened. Not unlike Andre van Rensburg, he too is of the opinion that winemakers do not have to be scared to put premium wines under metal.

- KANONKOP

The earliest records of trialling of closures in South Africa are to be found with the Paul Sauer 1983 bottled with a screw cap (Stelvin) and a natural cork closure (Amorim whole natural stopper). Two bottles were tasted at each of the London August 2003 and Stellenbosch November 2003 tastings. Details at best are sketchy as according to present day winemaker, Abrie Beeslaar, the tastings conducted were not “too scientific”, and as such yielded very little statistical data. The bottles had been stored under very different conditions, so it would be the sensory appeal of the wines which would distinguish them. According to Mr Beeslaar who attended the Stellenbosch tasting, the wine under screw cap did not show the fairly oxidative character that was evident on the cork closed sample. Both wines initially displayed bottle maturation characteristics as neither had been decanted prior to tasting. The cork closed bottle however showed more of a brown toned body colour than the Stelvin closed bottle. What has to be considered in respect of these two closures is that technologically the closures were not as sophisticated as today’s products and yet both held out and performed remarkably well. Naturally, a great deal of credit has to go to the winemaker and the fact that he created an exceptional wine to begin with.

Beyers Truter, having attended both tastings commented that at the London tasting the wine under screw cap certainly retained more of a fruity character whereas the wine under cork showed a better complexity of aromas. The ageing process, in respect of colour and taste factors, was deemed to have been quicker under cork.

Mr Beeslaar also indicated his own preference for a closure to be one which creates an airtight seal on the bottle and allows for no passage of the air. The concept of miniscule amounts of air passing through the cork is one which he dispels as being irrelevant as the varying degrees of cork quality would thus imply varying amounts of oxygen entering the wine. His ideal closure would be a glass sealed container. (16)

- DISTELL

No discussion about closures would be complete without having to consider the role played by South Africa's, Distell. With numerous brands under the belt all of whom occupy a specific niche and indeed have a very dedicated following, the choice of closure by the chain which comprises winemaker, brand manager, packaging department and sales force is as important as the quality of wine and bottle it is in. In a personal interview with Johan Truter, Group Packaging Manager for Distell, a very clear point was emphasised in that the aim of all winemaking operations throughout the group is that of oxygen control and at no time is that critical area of production to be compromised. Closures as such are viewed in this light.

The screwcap closures which are employed throughout the various ranges, all have a very definite role to play in the product profile. So that for example the shorter 31mmx22mm roll on pilferproof used for Capenheimer is one of the most affordable closures due to its size. The longer skirted offerings from MCG do command a slightly higher price and would be used for a more premium product. It's essentially horses for courses. Of interest is the unique capsule and lining which is used for Paarl Perle. First released onto the local market in the 1970s this closure was indeed an innovative product. The process for making a screwcap closure which would retain the carbon dioxide which distinguishes Paarl Perle is very different to that of the one for still, natural wines. The inner of the cap essentially does not have the PVPP disc but rather has molten PVC dripped into the cap. The cap is spun around so that the molten PVC spins out towards the end of the cap. These are then baked in an oven to set the PVC. When bottling the PVC almost bites into the bottle groove so as to ensure the retention of the carbon dioxide.

Another revolution was that of Tassenberg when it was launched in the 1940s. Not only did this wine become the archetypal red but it was amongst the first to be closed with a screwcap. It can be argued that such a wine with the following that it has, has indeed contributed to the perception of screwcaps being used for lower price point product. The closure is again a slightly shorter one, so that it is more cost effective.

At the time of writing, Distell were testing, researching and considering the wider use of alternative closures within the immense range it offers. However acceptance or rejection by the consumers appeared to be an area of great concern. Albeit that the buyers for the grocers wine license chains in the United Kingdom were at a time demanding screwcaps, and a considerable amount of pressure had been placed on the various brand managers to meet these requests.

- MAKRO

A particularly meaningful player in the South African wine industry, is the Makro chain of stores. Wine is sold through 6 of the 12 outlets, these which have “wine focus” sell an estimated 3.5 million bottles annually. Not unlike the international wine outlets which procure wine for their own in house labels, Makro deals with numerous of South Africa’s premium producers for limited release and specially bottled wines. In a discussion with Carolyn Barton, Makro’s wine buyer, she stated that according to the in-store wine consultants, the majority of their clients are still unaware as to what a corked bottle of wine is and so will not repurchase if they perceive the wine as not meeting expectations. These consultants estimate that they have returns of approximately 6 bottles per month due to taint or the wine being corked.

Makro also serve a function as a re-distributor so that should wines indeed be corked, the restaurant or on consumption venue will return the product to the wine producers distributor for credit or for replacement. As such Makro has limited financial implications in this regard. Mrs Barton replied to my question of bottling their own in house brands, under alternative closures, with a swift comment that synthetics had been trialed but met with more consumer resistance than the odd cork taint encountered bottle. She also feels that it is difficult for her to take a hard stand on closures, especially forcing her wine suppliers to move towards screw caps, when even the most committed of producers are only bottling half of a range, or only one wine in the range with a screw cap. In the medium priced to premium range of wines which have been bottled with a screw cap, Makro have Vergelegen, Kumkani, Flagstone and Augusta listed.

She summed up with a most apt commentary, “So I choose to sit on the fence and not force any specific requirements on suppliers for closures. Same as I cannot force them to use more attractive labels or pack all wines in 6-packs for my convenience. I am ultimately in the business of pleasing my customers who are still not educated enough to know what taint is, let alone what a corked wine is. What a wonderfully imperfect industry we work in!” (17)

## 6. CHANGING THE PARADIGMS OF CELLARING

“Corks are difficult little creatures to keep happy”, states Tyson Stelzer in his book, *screwed for good*. (14)

He continues to detail all the requirements which have to be met for proper cellaring, all of them so as to appease the cork. The rules for cellaring cork closed wines and screw capped wines differ to some extent.

The first condition to be met is that of a stable temperature in the designated cellar. Fluctuating temperatures cause the wine to expand and contract, thus resulting in pressure changes within the bottle. This leads to leaking corks and the loss of the stopper’s resilience and effectiveness over time. The results from Auscap (the leading Australian cap manufacturer) have shown screw caps pressure handling capabilities to be better than cork. However it should be pointed out that no matter what the closure, it is unquestionably better for the cellar to be at lower temperatures than higher ones, as the warmer environment (above 20°C) causes the wine to develop prematurely. (14)

Screw caps have absolutely no requirement for humidity to maintain the seal; unlike natural cork. There is a very fine balance to be maintained as regards the humidity in cellaring cork closed wines. A higher humidity prevents the cork from drying out and the wine evaporating, it however also encourages peeling of labels and moulds.

Screw cap closed wines have no requirements for storage and can be kept upright as opposed to cork closed wines which have to be laid horizontally to make certain that the cork is kept moist. The early detection of a broken seal would be the only reason to position screw capped bottles down or horizontally.

The impermeable seal of the screw cap ensures that no cellar odours will be absorbed by the closure and migrate into the wine. Thus no ‘off odours’ will taint the screw capped wine, as is the case with corked sealed wines.

The rules for cellaring screw capped wines are not new, as the above mentioned points were featured in the 1980 Wine and Spirit Buying Guide. The report ended as such, “The conclusions thus are that Stelvin does show a superiority to cork both in its oxygen inhibiting qualities and its ability to withstand storage conditions without affecting the wine.”

## 7. SUMMARY

In most circumstances it would appear to be the winemaker having reached the proverbial end of tether, pushing for the alternative. Wine consumption is certainly becoming more of a daily drinking process and as such consistency of product ought to be more important than ritual. Whilst the winemakers are understandably frustrated with natural cork, however at no time should they underestimate the cognitive effects of screw caps. Consumer education has to be undertaken to ensure that the benefits of these closures are understood and appreciated – it is not enough to assume that it is the more knowledgeable client who will purchase a capped bottle and thus extrapolate that it is, anyhow, this market segment to which they are appealing.

The aim of SASI (the South African Screw cap Initiative), founded in 2002 and co-ordinated by Lucy Warner, was to enable an exchange of information amongst the wine producers who had opted for or were considering the closure. Much was made of the trade tastings, public discussion forums and joint marketing ventures which were to have been undertaken. Regrettably, the reluctance of producers to join and share information or joint marketing efforts has resulted in this initiative being all but dead. Certain individual producers have forged ahead with the alternative closure, highlighting in Ms Warner's opinion the apathy and total inability of the South African wine industry to work cohesively.

Screw caps can be a viable alternative to cork but until there is more data on how they perform over the long term of ageing, there will be reluctance by a greater number of winemakers to bottle and by collectors to store. Tyson Stelzer (14) however is of a very different opinion, concluding the chapter headed 'peter pan wines' he states: "Extended ageing time might well be the only criticism that screw caps prove to live up to, but is this really a criticism at all? It is universally accepted that wines that age slower, age better. The very greatest old wines have matured slowly and elegantly, maintaining some of their fruit characters. Screw caps make this possible for every bottle, ironing out flat spots in a wine's development and elongating its ultimate drinking plateau. And if it does happen to take longer to get there, well, if the cap fits, we might just have to wear it."

What is certain is that the screw cap revolution's success will be determined by the consumers. Regardless of the strength of arguments or evidence, or the drive by retailers via their wine suppliers, it remains the consumer's choice to buy it, or not.

## CONCLUSION

Wine and the perfect closure indubitably have a long and bumpy road ahead. The great closure debate is one which will rage on for years to come. All producers, and indeed users of various closures are equally passionate and vehement about their products. The diverse screw cap initiatives and trials, and the ten year AWRI project should be closely watched for any surprises as these mammoth projects unfold and new data becomes available.

Natural cork might well be the corner stone of the industry today, but too many accepted standards are no longer in place having been superseded by technological innovations: 8 track cassette tapes or vinyl records by DVDs; carrier pigeons by email; passenger liners by supersonic flight - the transformations are endless. Bottle closures will change with the rapidly evolving aspects of technology and the dynamic nature of beverage products will ensure the evolution. After all, how much innovation and technological improvements are not seen in the wine industry every year with every harvest.

The author is of the opinion that there will be a niche for each closure; corks will indeed become more expensive as the research and development costs escalate in the pursuit of a taint free product. Thus their use will be limited to age worthy and premium products within most winemaker's portfolios. Synthetic closures will have their application in wines designed for early drinking and screw caps will remain the closure of choice of winemakers wanting to preserve their wines' intrinsic character at all costs. These winemakers will continue making a statement – be it a fashion or a contentious one. The quest for alternative to cork closures will undoubtedly be spearheaded by New World wine producers as upfront fruity wines are their signature.

The small metal crown cap as seen on beer, cider and alco-pop bottles has proven itself to be a reliable stopper over the years, yet it is probably the least fashionable or desirable consumer appealing closure. It does however provide for a cheap and efficient stopper and its use in sealing champagne bottles during the second fermentation phase has universal applications. Spectacularly brave would be the wine producer who ventured down this route to close mid to premium priced wines with this closure.

Ultimately it is the winemaker who makes the judgement call as to which closure he or she is prepared to place their proverbial necks on the line with, it is their name and reputation which inevitably sells the bottle. It is for this inherent reason that the alternative closure producers ought to be embarking on a more rigorous educational route to persuasion, so as to enlighten the winemaking fraternity who in turn can offer more substantial information to their ever attentive public. The screw cap producers – who have in the author's opinion the closure to take the wine industry beyond the current haranguing – certainly need to enhance their products' appeal to consumers, beyond any doubt.

The task will be to manage the transition efficiently and effectively.

## REFERENCES

- 1) Robinson, J: Oxford Companion to Wine, Oxford University Press 1994
- 2) Personal interviews December 2003 Joaquim SA – Amorim and links off [www.corkfacts.com](http://www.corkfacts.com)
- 3) Casey, J: Presentation at the National Conference of the International Wine Law Association, Adelaide Australia 25-27 October 2002
- 4) Wine Magazine SA November 2003
- 5) [www.enologyinternational.com](http://www.enologyinternational.com)
- 6) [www.awri.com.au/pettergodden](http://www.awri.com.au/pettergodden) et al:awri trials and results
- 7) Apcor Survey 16-31 January 2002  
[www.corkmasters.com/pressrelease\\_march2002](http://www.corkmasters.com/pressrelease_march2002)
- 8) Wine and Spirit Association Survey 2002 [www.corkfacts.com/november2002](http://www.corkfacts.com/november2002)
- 9) Quercus Survey [www.corkqc.com/tcaquercus.htm](http://www.corkqc.com/tcaquercus.htm)
- 10) Personal interview December 2003 Paul van Dooren (GM Supremecorq SA) and [www.supremecorq.com](http://www.supremecorq.com)
- 11) Personal interviews December 2003 Ken Bode and Steve Bell (MCG Industries SA Technical Manager and MCG Industries SA National Sales Manager) and [www.nomacorc.com](http://www.nomacorc.com)
- 12) Personal interview January 2004 James Reid (Operations Director Western Wines)
- 13) Personal interview December 2003 Johan Malan (Owner and winemaker Simonsig Family Vineyards)
- 14) Stelzer, T: screwed for good – the case for screwcaps on red wines, Wine Press Brisbane Australia 2003 ISBN 0958062811
- 15) Personal interviews Eddie Turner and Andre van Rensburg December 2003 (Vergelegen Marketing Director and Vergelegen winemaker)
- 16) Personal interview Abrie Beeslaar December 2003 (Kanonkop winemaker)
- 17) Personal interview Carolyn Barton December 2003 (Makro national wine buyer)

## ACKNOWLEDGEMENTS

- Daan Joubert for all the effort, energy, time and advice and for getting the ball into and indeed keeping it in motion.
- Marilyn Cooper, Andries Burger and Cathy White for all their encouragement.
- The Barns family for all the cheering on to “just do it” and for making available to me the most fabulous of environments, Mischa Estate, in which to work on this document.
- My parental unit who supported me tirelessly.....even from a distance.
- Steve Bell and Ken Bode – MCG Industries SA - not only for their help and assistance, but more to acknowledge the lessons in how to open a screw capped bottle correctly !
- Margie, Heidi and Junel, my longsuffering study group, what awesome friendships have resulted. I’ve yet to experience such camaraderie – albeit that a bottle of bubbles was always in reach to ease the agony !