Innovative Packaging for the Wine Industry: A Look at Wine Closures

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At an International Screwcap Symposium in November 2004, Peter Goddon from the Australian Wine Research Institute (AWRI) was quoted, “Closure variation may have a greater impact on wines and wine quality than the widely discussed and debated terroir issues. After about a month in the bottle, wines under different types of closures will never be the same.” Since the Australian industry first published consumer results of using different closure types on wines, the debate on closures has blown open. As of about ten years ago, natural cork was still the dominant closure type used for wine bottles (Phillips, 2007c). But since the age of technology has provided choices for winemakers in how they close their bottles, a range of synthetic corks to screw caps are now provided. The following report will highlight the history of wine closure packaging, five closure packaging possibilities used in the wine industry, their problems and benefits, and conclude with some insight what the future of wine packaging may entail.

WINE CLOSURE HISTORY

Wine. The word sounds simple enough, but in the past few decades, the scientific knowledge of the wine process has become so extensive that today’s winemakers are faced with a number of choices from the vineyard to the bottle. Wine closures are used to inhibit the extensive contact with oxygen, which causes oxidation of the wine (Robinson, 2006). Since wine has been manufactured, a number of different closure and bottle styles have been present through history. Amphoras were used by Ancient Romans and Greeks to inhibit the oxidation of wine completely (Robinson, 2006). In fact, a cork and pitch combination had been the primary seal for the amphoras (Phillips, 2000). However, when glass bottles were manufactured in the 17th century, a sealing system was needed for wine storage. Cork became the primary closure type due to the fact other materials were not capable of making an airtight seal to maintain the wine from turning into vinegar (Phillips, 2000; Robinson, 2006). Other methods used during that time period included glass stoppers and decanters, both of which are still applied in the industry today (Robinson, 2006). It is thought that the development of wine bottles and corks for wine packaging led to the development of sparkling wines and ports, which until the 17th century had never been seen before (Phillips, 2000).

Today, the wine closure industry has become heavily debated, creating a variety of closure types (*Figure 1*). What once was a cork-only industry has turned into an industry full of many choices. Cork bark can be used in two ways: as a natural cork or as a technical cork. Options for wine closures became more frequent when 2,4,6-trichloroanisole (TCA) was discovered to be one of the primary compounds responsible for cork taint. Due to economic losses by cork variability and cork taint contamination, the demand for new closure types was prevalent. However, each new closure type has its pros and cons when applied to wines of various styles and varieties. As many wine experts have noted, the closure type used for the wine bottle will ultimately, over time, alter the wine itself.

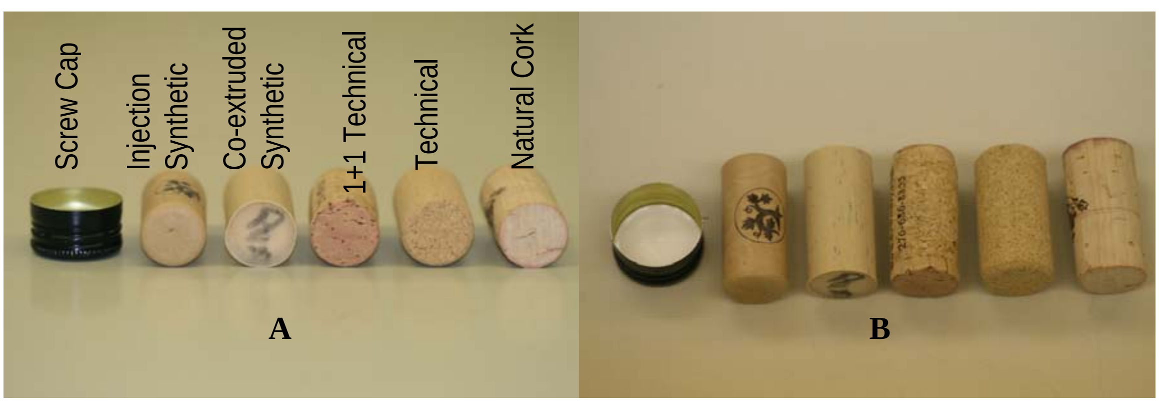

Figure 1: Various Types of Wine Closures Front View (A) and Side View (B)

NATURAL CORK

Natural cork closures are one of the oldest known forms of wine bottle packaging known, dating back to use in Tuscany during the 6^{th} century BC (Marin and Durham, 2007). Natural corks are made from the bark of oak trees (*Quercus suber)* (Phillips, 2007c). Cork is the regrown bark on the tree after the initial bark has been stripped (Lee and Simpson, 1993). The bark is harvested, seasoned, boiled, flattened, cut into strips, and punched in cork shapes (Phillips, 2007c; Robinson, 2006). Corks are checked for defects and some are branded or coated with a paraffin or silicone material (Phillips, 2007c). During processing, corks are also treated to minimize growth microorganisms, primarily molds and yeasts (Lee and Simpson, 1993).

This leads to one of the main problems with natural cork: the possibility of TCA contamination (Marin and Durham, 2007). In 1982, TCA was identified as the primary, but not only, chemical responsible for cork taint that causes a musty/moldy off-odor in the wine bottle (Buser et al., 1982; Evans et al., 1997; Lee and Simpson, 1993; Phillips, 2007c). It is generally believed that cork taint is caused by microorganism growth metabolites or by chemicals installed during cork processing (Pereira et al., 2000). Through 2003, it was guessed that up to 6% of all natural cork bottled wines were contaminated with cork taint implicating large economic losses (Lee and Simpson, 1993; Pereira et al., 2000; Riu et al., 2002; Walker, 2007).

In the past, the main way of treating natural corks involved chlorine dips or washes, but it believed this lead to an increase in TCA contamination (Robinson, 2006). TCA can be present at extremely small concentrations (1.4 – 10 ng/L) that caused a problem in identifying contamination cases during processing (Phillips, 2007c). However, recent improvement of cork manufacture has led to a dramatic decrease in cork taint occurrence. The development of solid-phase microextraction (SPME) for gas chromatography-mass spectrometry (GC-MS) gave cork manufacturers the opportunity to analyze corks more thoroughly, identifying TCA presence and quantifying its concentration (Phillips, 2007c). It was shown that SPME GC-MS could be "a rapid, sensitive, and precise analysis of TCA" even at its low concentrations (Evans et al., 1997). Through the use of SPME GC-MS, the cork industry implemented more rigorous processing quality control regulations in order to enhance the reputation of natural cork and compete with other alternative closure types that have been released on the market (Phillips, 2007c).

Additionally, another problem with natural cork involves the variability in oxygen permeability. It is a well known fact that natural cork allows for small amounts of oxygen to permeate through the cork, which in turn, allows wine to age gradually (Penn, 2007a). Too much or too little oxygen exposure can cause aging wines to oxidize or reduce, respectively, which alters the wine aroma and makes it unpleasant. The use of natural corks has been found to have an intermediate amount of oxygen transmission, compared to alternative closure types, into the wine during aging (Lopes et al., 2006). This is normally beneficial, but the rate at which aging takes place is variable among cork source, producer, and processing alterations to the cork itself (Lopes et al., 2006). Also, it has been noted that oxygen interaction and optimal amount of oxygen required for aging is highly dependent on wine style and variety (Phillips, 2007b).

Despite the threat of TCA contamination, natural cork remains one of the most popular closure types in the wine industry according to *Wine Business Monthly's* 2007 Closure Survey (Phillips, 2007a). Since the cork industry has enhanced its reliability in delivering untainted corks, perception and status of natural cork has improved (Phillips, 2007a). It was pointed out that higher priced wines, ranging from $14 and above per bottle, were most likely bottled by natural cork (Phillips, 2007a). This is, in part, is caused by the winemaker's belief that natural cork is the best closure type for aging wines (Phillips, 2007a). Aged wines are also higher priced, which correlates with the 2007 survey (Phillips, 2007a). The other part of continued use of natural cork in the wine industry today, especially in the United States, is driven by consumer perception. Through a number of sensory studies, it was found that consumers believe wines bottled with natural corks are of higher quality than wines bottled with alternative closures (Marin and Durham, 2007; Phillips, 2007a). It was found that many U.S. consumers believe alternative closures are used because they are cheaper than natural corks, and indicated that wines bottled with natural corks are of higher quality regardless of actual quality status (Marin and Durham, 2007).

Another large push for the cork industry is that has claimed to be "greener" than synthetic cork or screw cap production. *Wines and Vines*, a trade magazine, recently reiterated a UK study that claimed "1 million corks create 3.26 tons of carbon dioxide a year, while 1 million screwcaps are responsible for 14.27 tons" (Walker, 2007). Actually, many cork companies claim that with cork taint problems down, the main reason to invest in natural corks is due to its sustainability, to maintain the natural biodiversity that evolved with cork forests, and to support the industries that have been around for generations in Portugal, Italy, Spain, Algeria, Morocco, Tunisia, and France (Walker, 2007). With such benefits, wineries know that use of natural cork has profitable marketing potential.

TECHNICAL CORK

Technical corks, like natural corks, are derived from *Quercus suber*, but are conglomerates of leftover cork pieces (Phillips, 2007c; Robinson, 2006) (*Figure 2*). Cork is ground into small disks or pieces and glued together through a molding or extruding process (Phillips, 2007c). A number of technical corks exist currently on the market and differ in the way pieces are glued together. Processing is intricate, typically involving a series of washes, sterilization steps, and stabilizing procedures to minimize microorganism or TCA contamination (Amorin, 2007). Like natural corks, the main problem with technical corks is the possibility of TCA presence.

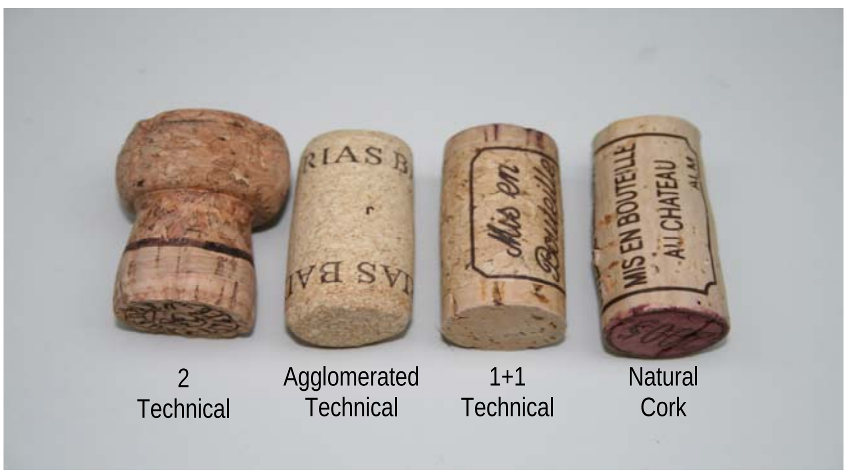

Figure 2: Various Types of Technical Corks versus Natural Cork

Several methods have been installed for the removal of TCA from technical corks. Steam distillation is one such method where steam heats the cork disk granules and boils off TCA (Phillips, 2007c). TCA is a relatively volatile compound, which allows the molecule to escape the cork material during steam distillation (Evans et al., 1997;

Phillips, 2007c; Riu et al., 2002). One company that specializes in technical cork manufacture found that steam distillation reduces TCA contamination by 80% (Amorin, 2007). Other treatments include the use of supercritical carbon dioxide, microwave radiation, ozone treatments, and hydrogen peroxide washes (Phillips, 2007c). Two relatively popular technical corks include Twin Top® and Neutrocork® (Amorin, 2007).

SYNTHETIC CORK

Synthetic corks from a plastic material and can be manufactured in a few different ways. One way involves a co-extrusion process, where one extrusion mold fills the inner core and a second forms the outer, smooth surface (Neocork, 2007; Nomacorc, 2007). One type of co-extruded cork is composed of low density polyethylene (LDPE) in the core and a LDPE-based thermoplastic elastomer surface coating (Neocork, 2007). Other synthetics are produced only by polymer injection (Zoecklein, 2004). Injection corks are made of thermoplastic elastomer mixes (Supreme Corq, 2007). An Italian manufacturer recently fought a patent battle with Supreme Corq, who tried to claim ownership of the plastics sytrene-butadiene-styrene (SBS) thermoplastic elastomer and styrene-ethylene/butadiene-styrene (SEBS) used to make injection synthetic corks (Mapleston, 2007). This company, Sigillo advertises the differences their cork composition showing how diverse synthetic corks are (Sigillo, 2007). More recent synthetic corks can also be formed through an extrusion and injection molding combination of an elastomer compound (Vinova, 2007).

General problems with synthetic corks revolve around transfer of oxygen into the bottle. Although a number of synthetic materials exist that can be used to manufacture these corks, it was found that these materials allow for greater oxygen permeation during wine storage, which oxidizes the wine (Lopes et al., 2006). This leads to oxidative aroma characteristics that are considered substantial by the wine industry. In fact, most wineries will use synthetics for wines that will be consumed within 12 – 18 months after bottling (Phillips, 2007a). This minimizes the negative effects caused by long term storage using a synthetic.

Synthetic corks are also known to be more difficult removing from the bottle (Phillips, 2007a). Synthetics get stuck in the neck of wine bottles and some corkscrews do not work with them at all. Most wineries are aware of this technical problem, and have made it known that they do not want their consumers to have difficultly when trying to open their bottles of wine (Phillips, 2007a).

The major benefit of synthetic corks is that it eliminates the possibility of cork taint that is caused by natural and technical cork use. This would be the primary purpose of using a synthetic cork. However, as noted through Enology Notes, synthetics also offer uniform weight, size, appearance and quality, as well as the fact that they do not retain moisture or break/crack (Zoecklein, 2005). According to the 2007 Closure Survey, synthetics are most commonly used for wines priced below $7 (Phillips, 2007a).

SCREW CAP

The screw cap has definitely come a long way since it was first released in the wine industry. The image portrayed by the screw cap is that it is only used for low quality wines. However, in 2001, Australia launched a large investigation around screw cap use in wines, and today, the majority of its industry is bottling wines with screw caps. However, the market for screw cap bottled wines in the U.S. struggles. Jane Robichaud from Tragon was quoted, “The U.S. market is very different from others. In the U.K. and

Australia, the acceptance of screw caps and synthetics is greater, while in France and the U.S. natural cork is still the closure of choice" (Phillips, 2007a).

One problem with screw caps is that they require special wine bottles (*Figure 3*). In order for the screw caps to actually fit, bottles have to be specially made to hold a screw cap setting. Nevertheless, the main problem with screw caps is the increased presence of wine reduction. Reduction involves the development of sulfur aromas due to the lack of oxygen transmission in the wine bottle (Goode, 2007). Such aromas can lead to rubber, stuck flint, vegetal, cabbagey, or mercaptan-smelling odors, which are highly undesirable (Goode, 2007).

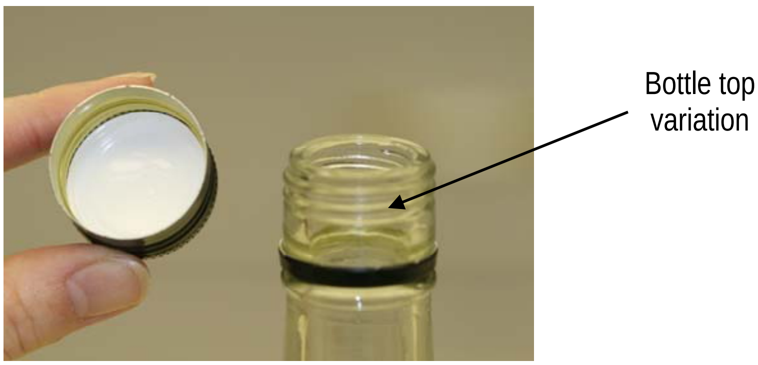

Figure 3: Screw Cap and Screw Cap Wine Bottle Variation

Two different liners are manufactured for screw caps used in the wine industry: 1. tin/Saran that is made of tin or aluminum and covered with a thin polyvinylidene chloride (PVDC) layer and 2. Saranex only that is made of only PVDC (Goode, 2007). It is the metal liner in the tin/Saran screw caps that inhibits oxygen transmission into the bottle and causes reduction (Goode, 2007). Saranex allows more oxygen transmission into the wine bottle, which reduces the reduction tones in the wine, but the tin/Saran is the most popular type of screw cap used by the wine industry (Goode, 2007). Some studies have shown that tin/Saran liners suppress oxygen transmission into the bottle (Lopes et al., 2006; Penn, 2007a).

Interestingly enough, despite the possibility of reduction aromas and flavors screw cap use is becoming more popular in the wine industry. The 2007 Closure Survey reported that although winemakers are aware of the reductive problem, it is not inhibiting them from using screw caps in wine packaging applications (Phillips, 2007a). This study also noted that winemakers believe consumers are becoming more accepting of screw cap use (Phillips, 2007a). The Australian industry is pushing use of screw caps for higher quality wines. The screw cap is now the standard closure for New Zealand wines (Tudor, 2005). In fact, some studies have shown that screw caps can have steady, minimal oxygen permeation (Tudor, 2005). As with other alternative closures, cork taint variability is not a problem with their use. It is believed that in time, the U.S. and other resistant countries will become more tolerant or screw cap benefits.

THE ZORK

The 2007 Closure Survey also found that some wineries are interested in the newly released Zork (Phillips, 2007a). Zork was initially produced and released in Australia in 2004, but Portola Packaging, Inc. based in the U.S. has obtained the rights to manufacture and sell the product (Penn, 2007b). Zork has three parts to it: a cap for protection, a foil lining that acts as an oxygen barrier, and a plunger application that creates the “pop” when the wine is opened as well as the ability to reseal the bottle (*Figure 4*) (Penn, 2007b).

Industry preliminary research shows that there is some oxidative development in the wine, much like a synthetic cork (Leske, 2007). Due to the fact that Zork is a relatively new product, its long-term capabilities with other wine closures is not comparable. It has not been included in up-to-date sensory trials or academic research.

Regardless, Zork is intended to maintain wine quality for up to 4 years and has the advantage of opening by hand as opposed to using a corkscrew (Leske, 2007). Again, like synthetic corks and screw caps, cork taint is also not an issue for this product. Unlike screw caps a special bottle is not needed for Zork application, and Zork sealed bottles do not exhibit reductive aromas and flavors (Leske, 2007). In addition, this new application is not tainted by market perception (Penn, 2007b). In other words, consumers do not have preconceived notions about the zork – its use is not thought of for low quality wines like screw caps. It is also fully recyclable (Leske, 2007).

THE FUTURE OF CLOSURES IN WINE PACKAGING

It is important to note, and a good way to conclude the differences among wine closures, that a number of different academic sensory studies have been conducted to evaluate the effects of closure types over time on various wine varieties. The major study that forced the wine industry into looking at various closure types was conducted in 2001 by Australian researches. This study looked at 14 different closures including screw caps, natural corks, synthetic corks, and technical corks (Field et al., 2001). Interestingly, it was noted that physical properties of natural cork Semillon wine were more variable than technical or synthetic corks (Field et al., 2001). Also, this study showed significant differences in wine aroma and flavor among sensory panelists (Field et al., 2001). In comparison, another study has shown that consumers cannot tell sensory differences among wines bottled with different closures when they are unaware of the closure type (Marin et al., 2007). Although research continues to dive into the long-term effects of closure types, each wine variety will have a specific way of interacting with packaging conditions. What is true for one wine variety may not be true for the next. Regardless, it is these studies that guide the industry into making their packaging and closure type decisions.

Figure 4: Corks of the Future! The "GS Elite" by Guala Group, Glass Closure, and Zork (From www.zork.com.au)

The fascinating part about wine packaging is the number of closure options available to winemakers today. In the last decade, new forms of closure technologies have developed in order to enhance wine storage conditions. Regardless of the continuous great debate about wine closures, a number of new closure types are still being created. Recently, Alcoa released a glass closure called the Vino-seal (or Vino-Lok), which sits on a synthetic O-ring and is held in place by a removable aluminum cap (*Figure 4*) (Alcoa, 2007). According to the 2007 Closure Survey, more and more wineries are interested in using the Vino-seal as well as the Zork for wines closures (Phillips, 2007a). In Italy alone, 400 wine cellars now produce wines bottled with the Guala Group synthetic GS Elite closure made of a chassis for adherence and elasticity, the body for oxygen permeation, and a shroud that remains in neutral contact with the wine (Guala, 2007). What once was a one-way sort of packaging, has become a series of options and possibilities that will only continue to develop with time… much like the wine itself.

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