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Wine Bottle Closures: A Rigorous Assessment

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Research and Development*

RESEARCH AND DEVELOPMENT



Outline

Introduction

Closure Types

- Natural cork
- Manufactured cork
- Synthetic closures
- ROTE

Strengths & Weaknesses

- Extraction force
- Flavor scalping
- Oxygen transmission rate (OTR)
- Post-bottling reduction
- Consumer acceptance

Conclusions



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Caveat emptor

“In the last few years, winemakers have been bombarded with a great number of opinions about the merits of different closures. Most of these opinions are, or derive from, commercial hyperbole, and there has been a conspicuous lack of reliable information about the relative overall performance of various closures.”

John Casey, *The Australian & New Zealand Grapegrower & Winemaker*, April 2002



Introduction

What constitutes the “ideal” closure?

Sealing issues

- Ease of application
 - Compatibility with existing equipment
- Ease of removal
 - Fragmentation/breakage
 - Specialized tool requirement
 - Ease of removal from tool
 - Ease of reinsertion
- Ruggedness
 - Handling
 - Temperature
 - Leakage
- Oxygen transfer rates

Sensory issues

- Taints
- Scalping
- Preservation of style
 - Oxidation
 - Reduction

Market issues

- Price
- Availability
- Aesthetics
- Consumer acceptance

Other Factors of Import

Fill height (ullage & resulting headspace O₂)

Insertion depth

Bottle neck variability

Bottle sparging

Dissolved O₂ at fill

Filler sanitation

Don't blame the closure if your process isn't in control!!!

***Caveat:* Your process probably isn't in control**

Closure Types

Natural cork

Technical cork

Synthetic closures

ROTE



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Natural Cork

PRO's

Light weight

Impermeable to liquids and gases (but not a hermetic seal)

Elastic and compressible

Renewable (and recyclable) resource

CON's

Being a natural product, it is subject to structural variation

- Structural faults can lead to oxidation and/or leakage

Of more concern, cork is subject to taints

Production process results in random variability both in structural faults and taint



Taint

Taint refers in general to

“unpleasant alterations in wine flavor or aroma”

- Silva Pereira et al., *Crit. Rev. Microbiol.* **26**:147, 2000

Taint is further differentiated from “off-flavor”

“Taint is defined as a taste or odor imparted by a foreign source”

- Butzke & Suprenant, UCCE Pub. 21571, 1997

As such taints can originate from a variety of sources

- Closures
- Bottles
- Barrels
- Environment



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Cork Taint – Solved?

International Wine Challenge data	2006	2007	2008
Total faults, %	7.1	NA	5.9
Corked - % of total faults (%)	27.8 (2.0%)	29.7	31.1 (1.8%)
Brett	10.6	12.8	15.8
Oxidized	24.3	22.9	19.1
Reduced	29.2	26.5	28.9

Chatonnet, The London International Wine Fair, 2009

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Or Not?

james laube unrefined ———

Cork Taint Is Sadly Still With Us

7 percent of wines tasted in our Napa office were corked

Posted: Jan 4, 2010 2:22pm ET

Wine Spectator senior editor James Laube reports that TCA taint is still with us, heading into 2010, and cork producers' claims that the problem has been solved and TCA taint is gone are highly debatable.

<http://www.winespectator.com/blogs/show/id/41497>

2,4,6-Trichloroanisole

2,4,6-trichloroanisole (TCA) is considered the most important sensory impact compound

- Estimated to be responsible for ~80% of cork taint incidences
- Detectable at ~2 – 4 ng/L
- Consumer rejection threshold at ~3 – 4 ng/L[†]

[†]Prescott et al., *Food Qual Pref* **16**:345, 2005. . .although note that 10% of the test subjects did not reject wines containing 32 ng/L!



Nota bene

Corks are not the only source of TCA contamination

- TCA taint vs. cork taint proper
 - Environmental contamination
 - Cross contamination
- Sources that affect the wine in bulk should not result in the bottle to bottle taint variation typically observed
 - If level in bulk lot is high enough, wine won't get bottled
 - Probably only significant for bottled wine if sub-threshold from environment combines with sub-threshold from closure to exceed threshold when added together

Manufactured Corks

PRO's

All the natural cork
Pro's

Being manufactured
products, they are
more uniform

Smaller cork
granules and disks
easier to strip of TCA

Less expensive

CON's

Manufactured corks
are still subject to
haloanisole taint

Glues may impart
taints

Lower OTR's than
natural cork

Higher extraction
forces

Manufactured Corks

Problems with source cork material

- Scraps and sweepings from natural cork production
- Remediation strategies
 - Steam (*e.g.*, Amorim's ROSA process; Cork Supply's VAPEX process)
 - Supercritical CO₂ (*e.g.*, Oeneo's DIAMANT process)
 - Microwave (*e.g.*, Juvenal's DELFIN process)
 - Barriers (*e.g.*, ProCork's membranes)

Problems with glues and binders

- Sabate's (Oeneo) Altec (Diam)

Ironically, the glue on technical corks might actually provide an oxygen barrier of its own



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Synthetic Corks

PRO's

Being manufactured products, they are more uniform

TCA-free

Less expensive

No supply concerns

Can be colored

Preserve cork "pop"

CON's

Extraction force

Reinsertion

OTR

Consumer acceptance

- Plastic taints
- Flavor scalping
- "Green" perception



Molded vs. Extruded

Molded

- Closed end cap
- Low gas permeability
- Chamfered edges
- Can be inserted with Auto Corking equipment
- Quickly deforms to compensate for bottle irregularities
- Can have inconsistent cell structure and foam density
- Can be difficult to extract from bottle, particularly when chilled

Extruded

- Continuous process
- Consistent cell structure and density
- Low gas permeability
- Can be inserted with Auto Corking equipment
- Open cell structure ends
- Stiff outer layer can slow conforming of cork to bottle
- Can be difficult to extract from bottle, particularly when chilled



Extraction Force

The ease of extraction depends on the structure and surface treatment of the closure, both of which affect the friction between the closure and the bottle neck

The force of extraction should be > 147 N (15 kg) to insure a sufficient closure seal; optimal extraction force is considered to be $\sim 290 - 340$ N (30 – 35 kg)

Extraction forces over 440 N (45 kg) are problematic for easy closure removal



Extraction Force

Natural corks typically exhibit extraction forces of 220 – 350 N (22 – 36 kg)

Technical corks exhibit extraction forces of 295 – 590 N (30 – 60 kg)

Synthetic closures exhibit a large variability in extraction force 100 – 500 N (10 – 50 kg); however, commercial synthetic corks *of a given type* do not typically exhibit this large a variability. In general, all synthetics tend to average toward the high end of the force range 390 – 590 N (40 – 60 kg) at chilled (~ 4 °C) temperatures



Flavor Scalping

Synthetic corks were found to be competitive with natural corks in regards to flavor scalping (Ortiz, 2004); this was also found in research conducted by SupremeCorq in association with Oregon State University

Esters and TDN (1,1,6-trimethyl-1,2-dihydronaphthalene) were found to be scalped by synthetics (Capone et al., *Wine Industry J* **18**:16, 2003)



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Synthetic Corks

"Look," said Roark. "The famous flutings on the famous columns--what are they there for? To hide the joints in wood--when columns were made of wood, only these aren't, they're marble. The triglyphs, what are they? Wood. Wooden beams, the way they had to be laid when people began to build wooden shacks. Your Greeks took marble and they made copies of their wooden structures out of it, because others had done it that way. Then your masters of the Renaissance came along and made copies in plaster of copies in marble of copies in wood. Now here we are, making copies in steel and concrete of copies in plaster of copies in marble of copies in wood. Why?"

A. Rand, *The Fountainhead*, 1941



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ROTE

PRO's

TCA-free

No opening tool required

Ease of resealing

Less expensive

Recyclable

Choice of liners

CON's

Durability

Low OTR's

Requires special bottle

- Standard ROTE bottles have excessive headspace

Requires special bottling equipment

Consumer acceptance



ROTE

It is not the aluminum cap which provides the much sought after impermeable gas barrier but rather the liner: a film of tin foil less than a 15th of a millimeter thick. This is separated from the wine by a very thin film of inert PVDC (polyvinylidene chloride, *a.k.a* Saran). PVDC is a solid (not gas blown) plastic polymer; this un-pigmented pre-shrunk film is laminated to the tin of the capsule. However, the aluminum cap itself limits oxygen exposure to the edge of the liner seal.

During the capping process the central polyethylene section of the liner is compressed over the end of the bottle and so forms the seal. The polyethylene disc lends the elastic resilience to maintain the liner's compression.

after Berenice Barker, *Bottle Closures in the Wine Industry*,
Cape Wine Academy Dissertation, 2004

Oxygen Transmission Rate

OTR is a Goldilocks phenomenon: you can have too little or too much

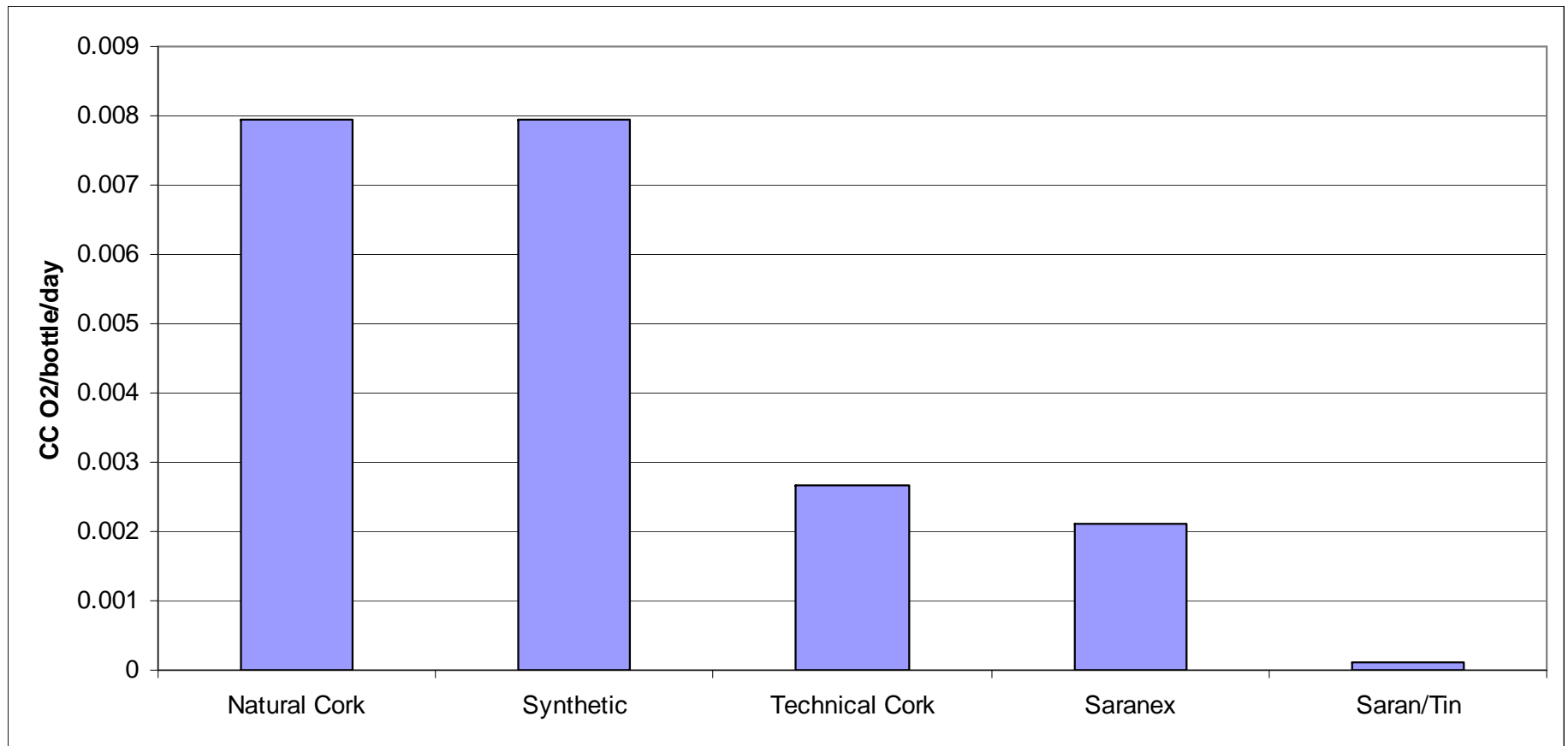
Too little O₂ in bottle leads to reduced aromas in susceptible wines

- Sulfide-like odors (SLO's)

Too much O₂ in bottle leads to oxidation

- Early maturation
- Browning
- Elevated volatile acidity

OTR Closure Comparison

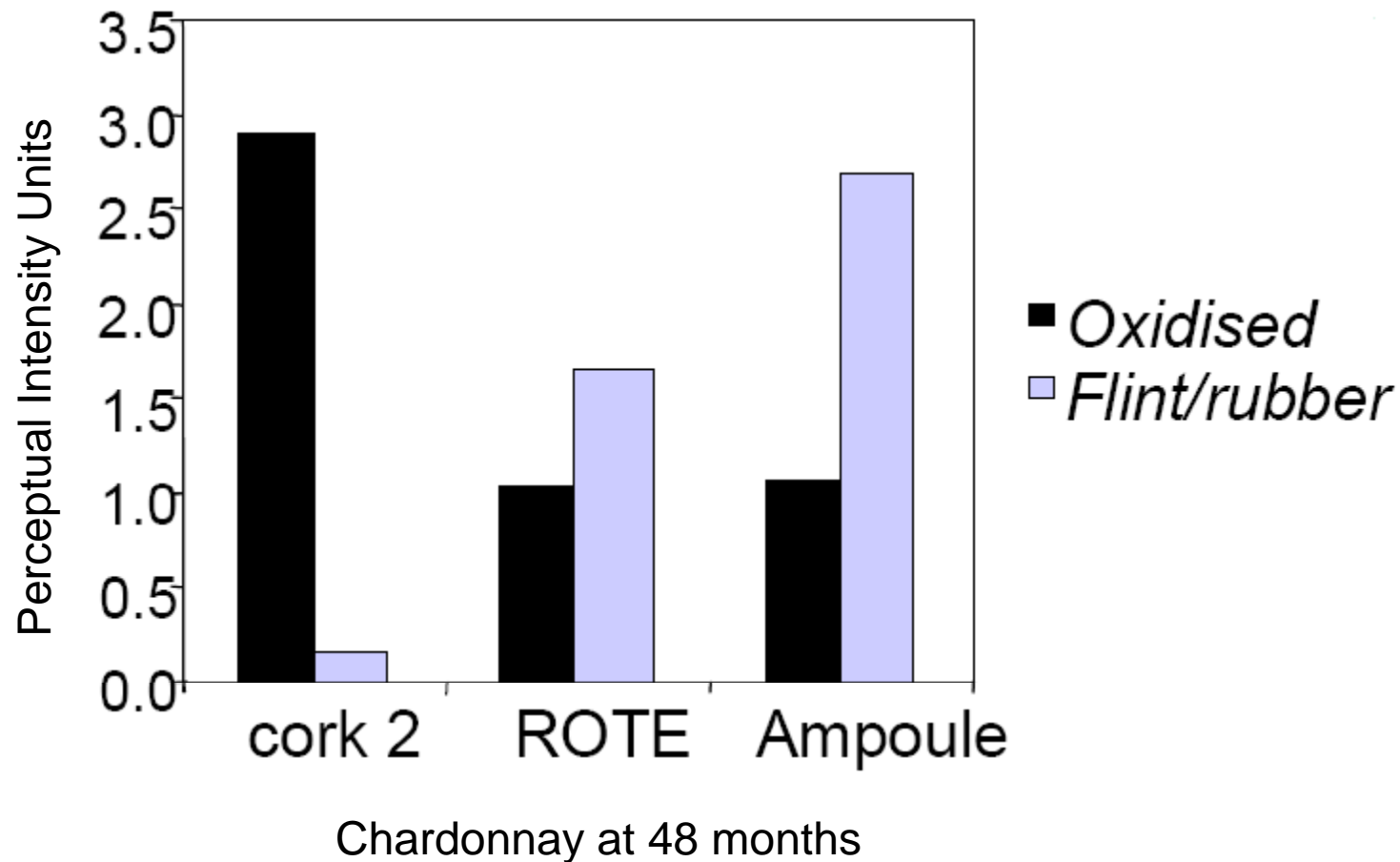


Mocon data

!

Chatonnet, The London International Wine Fair, 2009

Post-bottling Reduction



Godden et al., *First International Screw Cap Symposium*, NZSCI, 2004



Measuring OTR

MOCON testing has been the conventional method for determining OTR's

- Disadvantage 1: the closure is tested dry
- Disadvantage 2: the bottle neck is severed from the bottle

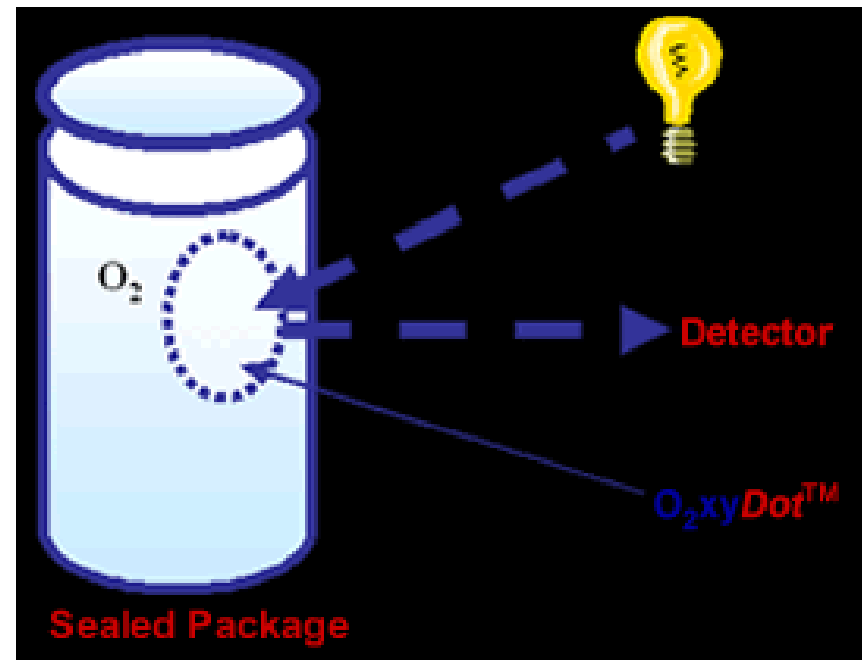
Luminescent methods bypass those restrictions

- A dye is excited by a specific wavelength of incident light
- As the excited electrons decay to their ground state a characteristic wavelength of light is emitted (fluorescence)
- The intensity of the fluoresced wavelength is proportional to the pO_2

Luminescent Detection

Using fluorescent “dots” you can actually continuously measure O_2 in the headspace and liquid of a wine over time

Furthermore, with clear glass, you can put a “dotted” bottle through your bottling process to assess the level of O_2 uptake



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Consumer Acceptance

United States consumers are:

More influenced by closure type; natural cork is preferred, followed by synthetic; screw cap is a negative factor, especially for \$15+

However, for U.S. consumers who frequently purchase wines for less than \$8.00, price was more important than closure type.

There was no group of consumers who preferred screw cap closed wines.

Bleibaum et al., 6th Pangborn Sensory Science Symposium, 2005

Consumer Acceptance

Chardonnay and Merlot wines were bottled under three different closures and evaluated at 33 months

Wine consumers were asked to evaluate sensory differences; in a second experiment consumers were asked to hedonically rate wines without and then with closure knowledge

Wine consumers could not detect sensorial differences among Chardonnay and Merlot wine samples sealed with natural, synthetic, or screw cap closures

Consumer Acceptance

For Chardonnay:

- the knowledge that the wine was sealed with a natural cork did not significantly affect the liking or quality scores.
- when participants knew that the sample was bottled with a synthetic cork, the liking score tended to be lower and the difference was nearly significant, but quality ratings did not change.
- when participants learned the wine had a screw cap, both the liking and quality ratings were significantly lower

For Merlot: there was no change in liking scores for any of the closures, but quality scores for the wine with a natural cork increased significantly

Marin et al., *AJEV* 58:182, 2007



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Conclusion

“It is now clear that closure choice is not just a packaging issue – it is also a winemaking one. If you are a winemaker, how you treat your wine just before bottling and your choice of closure are decisions that have an important effect on how the wine will taste when it reaches the consumer.”

Jaime Goode, “The Closure Debate: An Overview”
Harpers Wine & Spirits Closures Supplement,
December 2005

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