An *In Vivo* Study

Sanitation of wine cooperage with five different treatment methods

Oak barrels are expensive, made of porous, layered wood, and inevitably harbor microorganisms. Sanitizing them can be a challenge.

PHOTOS BY CHELSEA GALLUP

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Oak barrels are a particularly challenging part of winery sanitation. While there are many sanitizing options available, rigorous, side-by-side comparisons are required to know which treatments are more or less effective.

In a recent study, we compared five sanitizers: sulfur dioxide, peroxyacetic acid (PAA), steam, chlorine dioxide and ozone at varying times or concentrations. The sulfur dioxide, steam, ozone and PAA at higher concentrations were all found to be effective sanitizers, but the lower concentration of PAA and chlorine dioxide did not significantly reduce the number of spoilage organisms. As with any sanitizing treatment, it is important first to have an effective cleaning step to remove dirt and debris.

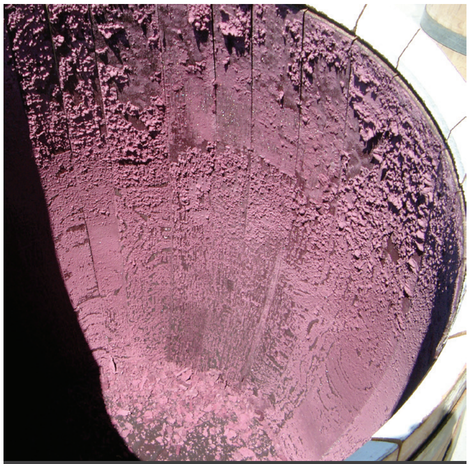
KEY CONCEPTS

- Cleaning is removing dirt and debris, while sanitizing is a 99.9% reduction in microorganisms. Cleaning is an essential first step before any sanitizing can occur.
- Sanitizers have different characteristics and perform differently. Carefully monitor concentrations and/or contact times to ensure efficacy.
- Proper protective equipment and ventilation is required when using any sanitizer

Introduction

Oak barrels are a source of significant cost and effort in wineries where they are employed. Expensive to procure and challenging to maintain, barrels have some significant disadvantages when it comes to sanitation. First, it is impossible to "sanitize" a barrel the way one sanitizes a stainless steel tank. It harbors large amounts of microorganisms the day it arrives at the winery, and it will continue to do so when it is turned into a planter.

Oak is a living organism, and the wood is naturally porous and layered. There are nooks and crannies that cannot be penetrated without destroying the wood and/or trapping residues of the cleaning agent. The implications of such limits are fairly serious, because barrels that get beyond management will most likely have to be discarded, and the only thing more costly than buying a new barrel is tossing one.

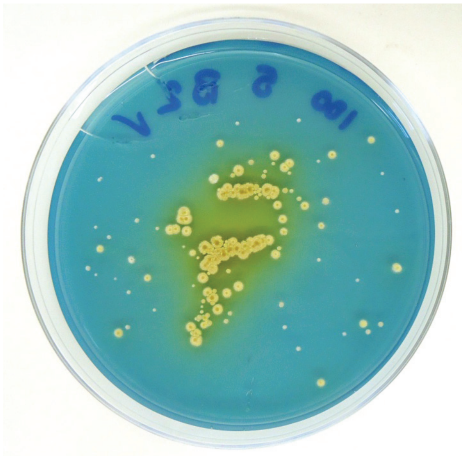


Barrel interior before treatment. Note the obvious tartrate accumulation, indicating insufficient cleaning.

Cleaning versus sanitizing

When thinking about barrels and sanitation programs, it is important to remember the difference between cleaning and sanitizing. Cleaning is the removal of dirt and debris, while sanitizing is reducing the number of microorganisms. Cleaning is a physical act, such as scrubbing with a brush or spraying with a hose, while sanitizing involves introducing a chemical agent that will kill yeast, bacteria and mold. It is important to remember that **without thorough cleaning, no sanitizer will be effective** (see photo above).

The Environmental Protection Agency defines sanitizing as a 99.9% or 3 log reduction in the number of microorganisms. Barrels are a challenge to both clean and sanitize because of the small access point (the bung hole), the porous surface and the risk of ruining the wood. Tartrates are the most abundant



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Environmental *Brettanomyces* isolated from "naturally" contaminated barrels.

Table I. Results of barrel sanitation treatments

Treatment	Concentration/ Duration	Efficacy	Notes
Sulfur dioxide disc	3 weeks	Good	No difference between 3 and 6 weeks
Sulfur dioxide disc	6 weeks	Good	No difference between 3 and 6 weeks
Peroxyacetic acid	120 mg/L	Poor	
Peroxyacetic acid	200 mg/L	Good	
Steam	5 minutes	Good	Small numbers of non-spoilage yeast detected
Steam	10 minutes	Good	Small numbers of non-spoilage yeast detected
Ozone 1 mg/L	5 minutes	Good	Poor results from a few barrels, possibly related to insufficient cleaning step.
Ozone 1 mg/L	10 minutes	Good	Poor results from a few barrels, possibly related to insufficient cleaning step.
Chlorine dioxide	5 mg/L	Poor	
Chlorine dioxide	10 mg/L	Poor	

organic material that must be targeted for removal prior to sanitation.

Brettanomyces/Dekkera ("Brett") yeast species are the most feared barrel spoilage organism. Brett is opportunistic, taking advantage of the high pH and low SO_2 levels in many red wines as well as some of the byproducts of oak toasting found in barrels.

Oak provides the perfect environment for Brett because of the porous surface and the inability to use powerful detergents or chemical sanitizers. Wines that have been infected by Brett can be described as smelling like smoke, Band-Aid, horse blanket, barnyard, clove and more.

Removing the organisms from the wine (through filtration or other means) will do nothing to eliminate the associated aromas, so preventing a viable population from forming is essential.

Barrel sanitation study

Maria Alejandra Aguilar Solis, a graduate student in Dr. Randy Worobo's laboratory, traveled to three wineries located in Napa, Calif., to conduct an *in vivo* study of spoilage organisms in barrels.

The experiment included 100 "naturally contaminated" barrels from a few

When sampling from wine barrels in the winery, Randy Worobo recommends taking a container of hot water (more than 180° F) along to clean the thief after each barrel sampling to prevent cross-barrel contamination.

different wineries and compared five treatments: sulfur dioxide, peroxyacetic acid, steam, chlorine dioxide and ozone.

Each treatment was applied at varying concentrations (peroxyacetic acid, chlorine dioxide) or varying lengths of time (sulfur dioxide, steam, ozone). Each barrel was evaluated before and after treatment, and the total yeast populations—*Zygosaccharomyces bailii* (a re-fermentation risk) and *Brettanomyces* yeasts (see above)—were compared.

Wood core samples were taken before and after treatment to count cells below the surface.

Sulfur dioxide (SO_2) is the preferred protective additive used in wine because of its dual antioxidant/antimicrobial abilities. In this case, sulfur discs are burned in clean, dry, empty barrels. These discs create gaseous SO_2, which prevents the growth of microorganisms over a long period of time. In this study, barrels were evaluated after three and six weeks. The longer treatment time was found to be statistically just as good as the shorter one, indicating that effective sanitation can maintain spoilage-free conditions for long periods of time provided there is no re-contamination.

Peroxyacetic acid (PAA) is a mixture of peracetic acid and hydrogen peroxide, which is an effective sanitizer over a wide range

Table II. Relative strengths and weaknesses of sanitizers

Treatment	Advantages	Disadvantages
Sulfur dioxide	Effective against wine spoilage microorganisms Very inexpensive	pH dependence on efficacy (effective at lower pH, not as effective at higher pH) Some yeast species are relatively tolerant
Peroxyacetic acid	Effective at low concentrations, kills spores Breaks down to nontoxic species	Corrosive with long contact times Relatively unstable
Steam	Effective against all juice and wine microorganisms Nontoxic materials	High energy input Can damage/ degrade fittings, gaskets
Ozone	Effective against all microorganisms, decomposes biofilms at early stages of development Breaks down to nontoxic species	Breaks down extremely rapidly/ inactivated easily Can damage/degrade rubber fittings gaskets, some metals
Chlorine dioxide	Effective in low concentrations Can be produced onsite	Byproducts are toxic Organic matter binds the chlorine

NOTE: All sanitizers require proper protective equipment and/or adequate ventilation and must be used according to the manufacturer's specifications.
Reference: Wirtanan & Salo 2005, R. Worobo, unpublished

of temperatures and pH levels, works at low concentrations and oxidizes quickly to fairly safe species (acetic acid and water), so residue is not a concern. In this situation, PAA was examined at two concentrations—120 mg/L and 200 mg/L—and the higher concentration was found to be effective while the lower was not. PAA did not control *Zygosaccharomyces* as well as other sanitizers in the trial.

Steam will inactivate/kill every wine spoilage organism, and it is (of course) just boiling water in the gas form. The challenge is to make sure that every part of the item to be sanitized gets hot enough for long enough (generally

Steam treatment equipment used for the steam portion of the barrel study.

agreed to be around 180° F at 25 to 35 psi). In both five- and 10-minute treatments, steam was effective at eliminating all spoilage yeast, although low levels of non-spoilage yeasts were still detected. As a safeguard to prevent post-steaming contamination, covering or closing the bung hole is recommended, as is proper handling of barrels after cleaning and sanitizing.

Chlorine dioxide (ClO_2) is an oxidizer that is related to but distinct from hypochlorite (bleach). It is known to be as effective as other chlorine-based clean-

ers, but there is no established link between chlorine dioxide and TCA (cork taint), as is the case for other chlorinated sanitizers. In this study chlorine dioxide was not shown to be effective in either 5 mg/L or 10 mg/L concentrations against any of the yeast populations. This may be explained by the fact that chlorinated sanitizers can bind to organic matter, and the barrels are organic matter.

Ozone is an oxidizer that is created electrically in a winery. Ozone has no problems with resistance, no limits of temperature or pH, and no problems with residues or metal corrosion. Ozone has a very short half-life, however, and must be produced constantly. Ozone at 1 mg/L applied for 5 or 10 minutes was effective against all yeast populations for both time periods in most of the barrels but not all, with potential issues being the initial population or an ineffective cleaning prior to ozone treatment.

This study demonstrated some differences in the performance of common sanitizers when challenged with *Brettanomyces* in barrels. Each type of sanitation treatment has its strengths and weaknesses, summarized in Table II. PWV

This article is adapted from a text originally published in *Appellation Cornell*, Issue #15, August 2013, a publication of the Cornell Viticulture & Enology program.

Acknowledgements. The authors would like to thank Constellation Brands and Francis Ford Coppola Winery for providing the workspace, barrels, labor and laboratory assistance in California.

Bibliography

1. G. Wirtanen and S. Salo. 2003. "Disinfection in food processing—efficacy testing of disinfectants." Reviews in *Environmental Science & Biotechnology* Vol. 2, Issue 2-4, pp 293–306

BARREL SANITATION SUPPLIERS

Company	Phone	Website	Barrel Washers	Cleaning/Sterilization Equipment
Aaquatools Inc.	(800) 777-2922	aaquatools.com	✓	✓
AO Wilson Ltd.	(519) 833-0400	aowilson.ca		✓
AP Welding & Consulting Inc.	(805) 235-0729	bwga.net	✓	✓
ARS/Swash Cleaning and Sanitization	(707) 942-8330	cleanwinery.com	✓	✓
Barrel Blasting Inc.	(707) 312-9084	barrelblasting.com	✓	
Carlsen & Associates	(707) 431-2000	carlsenassociates.com	✓	✓
Complete Welders Supply	(707) 258-0885	completewelderssupply.com		✓
DEL Ozone	(800) 676-1335	delozonefoodsafety.com		✓
Electro-Steam Generator Corp.	(866) 617-0764	electrosteam.com	✓	✓
Euro-Machines Inc.	(707) 864-5800	euromachinesusa.com		✓
Gamajet, part of the Alfa Laval Group	(610) 408-9940	gamajet.com	✓	✓
GW Kent Inc.	(734) 572-1300	gwkent.com	✓	
J Scott Co./Lechler	(707) 762-3838	jscottcompany.com		✓
Kinnek	(800) 784-3151	kinnek.com	✓	
Krones Inc.	(414) 409-4000	kronesusa.com		✓
Lechler Inc.	(800) 777-2926	lechlerusa.com		✓
Logic Inc.	(608) 658-2866	ecologiccleansers.com		✓
miwinebarrel	(800) 727-6294	miwinebarrel.com	✓	
Napa Fermentation Supplies	(707) 255-6372	napafermentation.com		✓
Parker Hannifin	(978) 858-0505	balstonfilters.com		✓
Paul Mueller Co.	(800) 683-5537	paulmueller.com		✓
Placer Process Systems Inc.	(877) 251-6082	placerprocess.com		✓
Process Engineers Inc.	(510) 782-5122	peiequipment.com		✓
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Tom Beard Co.	(707) 573-3150	tombeard.com	✓	✓
Western Square Industries Inc.	(800) 367-8383	westernsquare.com	✓	

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