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Research Focus

Sanitation of Wine Cooperage using Five Different Treatment Methods: an *In Vivo* study

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

Photos by Chelsea Gallup

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 to have an effective cleaning step first 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 take place.
- 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's impossible to "sanitize" a barrel, at least 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 part of a living organism, and the wood is naturally porous and layered. There are nooks and crannies that can't 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 it.

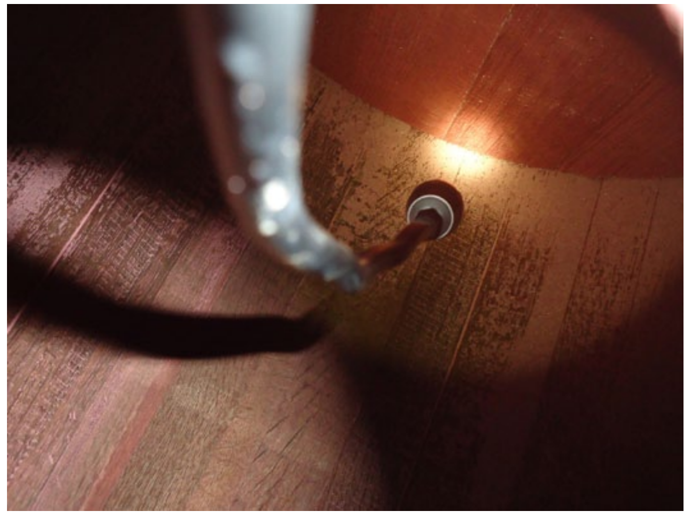

Photo by Maria de Lourdes Alejandra Aguilar Solis

Figure 1: *Barrel interior before treatment. Note the obvious tartrate accumulation, indicating insufficient cleaning.*

Cleaning versus sanitizing. When thinking about barrels and sanitation programs, it's 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 molds. It's important to remember that **<u>without thorough cleaning, no sanitizer will be effective</u>** ***(****See Figure 1).*

The EPA 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 porous surface and the risk of ruining the wood. Tartrates are the most abundant 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 higher pH and lower 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.

Photo by Maria de Lourdes Alejandra Aguilar Solis

Figure 2: *Steam treatment equipment used for the steam portion of the barrel study.*

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

The experiment used 100 "naturally contaminated" barrels from a few 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 also 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 anti-oxidant/ 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 of temperatures and pHs, 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.

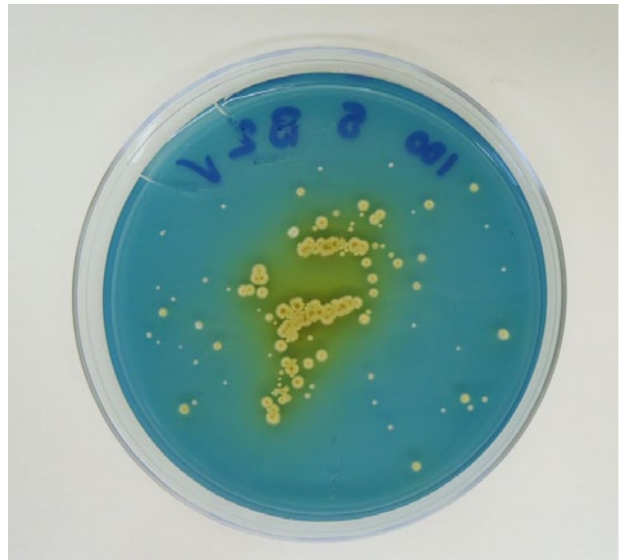

Photo by Maria de Lourdes Aguilar Solis

Figure 3: *Environmental Brettanomyces isolated from "naturally" contaminated barrels.*

Table 1. 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	

Table 2. 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

Winery Sanitation Survey - Please Participate:

We are currently conducting a survey of winery sanitation practices, and would appreciate your participation. To participate, please go to:

https://cornell.qualtrics.com/SE/?SID=SV_e2sm3bnLJTJ3Rrv

- **Steam** will inactivate/kill every wine spoilage organism and it is, of course, just really boiling water that is 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 agreed to be around 180°F). In both the 5 and 10 minute steam treatments, it was effective at eliminating all spoilage yeast, although low levels of non-spoilage yeasts were still detected.

- **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 cleaners but there is no established link between chlorine dioxide and TCA (cork taint), as is the case for other chlorinated sanitizers. In this study it was not shown to be effective in either 5 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 another 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 2.**

Reference

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

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