High power ultrasonics for killing spoilage organisms and oak barrel cleaning

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Background

Aging wine in oak barrels, especially red wine, is one of the major contributors in producing high quality wine. As such wineries invest a significant amount of capital in oak barrels and if possible re-use them over several vintages. As such barrel management requires significant attention to avoid the buildup of tartrates or microbial spoilage organisms, like *Brettanomyces/Dekkera* and acetic acid bacteria, on or in the oak wood matrix[1].

Conventional methods for barrel cleaning/sanitisation include hot water and chemical treatments, and due to the porous nature of the oak are often ineffective at removing tartrate buildup and/or microbial spoilage organisms[2]. Therefore there is an opportunity in this area to apply new technologies. One of these, commonly used in other food industries, is high power ultrasound (HPU). HPU causes the formation and collapse of high-energy micro-bubbles (cavitation). The three types of energy released from cavitation are shock waves which transfer kinetic energy, acoustic streaming which transfers heat and mass, and vibration which reduces surface friction. As such HPU has potential applications in cleaning of surfaces, including porous ones, such as the interior of oak barrels, as well as the inactivation of microorganisms. This paper reports on an investigation of the effectiveness of HPU in cleaning the interior of oak barrels and killing of spoilage organisms including *Dekkera/Brettanomyces* yeasts.

Potassium tartrate removal

Potassium tartrate is one of the major precipitates that foul the inside of wine barrels (Fig 1), is very difficult to remove by conventional water washing, and is an ideal place to harbour wine spoilage organisms. The application of HPU clearly demonstrates that this technology is able to remove tartrate deposits (Fig 2).

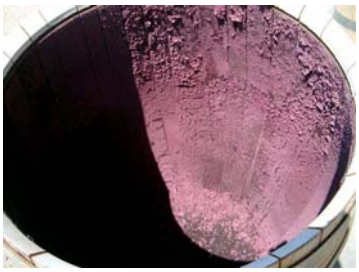

Figure 1. A 3-year old barrel cleaned with town-supply water pressure cold water applied through a large hose with a spray ball. (Picture A. Yap)

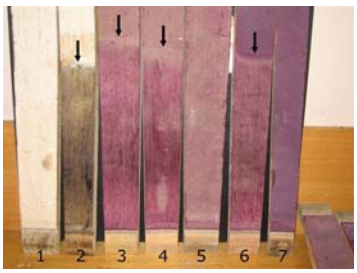

Figure 2. Staves 1 and 2 were obtained from a 6-year old barrique that had been in constant use since 2001 for white fermentations only. Both staves were entirely covered with thick (2-3 mm) and hard solid residues (tartrates, yeast lees, etc.). At each vintage juice was fermented in the barrel, the wine racked once and the barrel was quickly cleaned with a barrel washer to remove lees. The bottom half (below the arrow) of Stave 2 was ultrasonically treated for 5 minutes. Note the complete absence of tartrate and yeast lees. Staves 3–7 were obtained from a 6-year old barrique that had been used since 2001 for red wine maturation. The barrel had been cleaned with a low pressure cold and hot water barrel washing system annually between 2001 and 2004, and with a high pressure (3000 psi) hot and cold water cleaning system in 2005 and 2006. The barrel was cleaned about 4 times a year and was last cleaned in December 2006. It was dismantled for the trial in February 2007. The bottom halves (below the arrows) of Staves 4, 3 and 6 were treated ultrasonically for, 3, 7 and 10 min, respectively. Staves 5 and 7 were untreated. Note the complete removal of tartrates and considerable reduction of colour pigments (cf Stave 7) in the portion of Stave 6 below the arrow. The tartrate deposits on the untreated staves were hard, with thickness ranging from 2–4 mm. (Taken from Yap et al[2])

Control of wine spoilage organisms

Wine spoilage organisms, in particular *Dekkera bruxellensis*, render barrels useless. Deliberately infected stave pieces with *D. bruxellensis* AWRI 1499, were placed inside a wine barrel and treated with HPU or pressurised hot water. The killing potential of these methods was ascertained by determining the number of colony forming units within the first 2 mm of oak. The results (Table 1) clearly show that hot water washes (60°C) do eliminate some cells present on the wood. In contrast, HPU sanitisation causes a high degree of killing (up to 100%, Table 2), especially at water temperatures of 60°C.

Table 1. Cell counts (CFU/mm^3) from high pressure hot water treated surface slices of 1 year old staves. Means and standard errors (SE) are from triplicate samples.

	Barrel Position							
Time (min)	1	SE	2	SE	3	SE	4	SE
3	142.9	28.2	579.9	103.5	208.4	35.7	133.1	16.0
5	247.7	73.4	116.2	23.7	88.4	15.1	88.4	15.8
8	68.2	9.0	295.7	120.5	100.4	97.9	100.4	12.0

Control = 781.1

Table 2. Cell counts (CFU/mm^3) from HPU treated surface slices of 1 year old staves. Means and standard errors (SE) are from triplicate samples.

	Time (min)					
Temp	5	SE	8	SE	12	SE
40°C	44.2	7.1	200.8	23.0	176.8	30.4
50°C	12.0	3.5	9.7	0.9	0.0	0.0
60°C	0.0	0.0	0.0	0.0	0.0	0.0

Control = 372.4

Effect on oak flavour extraction

Oak flavour extraction from wine barrels contributes greatly to the final quality of red and some white wine styles. Furanic compounds, such as furfural and 4-methylfurfural, are ideal performance indicators to compare the impact of different cleaning techniques, due to its desirability and in oak barrels[3] and hence wine. Several studies carried out in Australia and California show that wines stored in oak barrels (1 to 5 years old, treated by HPU or hot water high pressure) show at worst no significant increase or at best a 2 to 3 fold increase in furanic compounds in barrels treated by HPU (data not shown) .

Summary

These combined studies suggest that HPU is an alternative method for successful barrel management in wineries. In addition to the removal of tartrates, HPU is also very efficient at controlling wine spoilage microorganisms. The cost/saving benefits of this technology may be quite substantial. On going research is evaluating the full potential of this technology.

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Acknowledgements

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