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Effect of Screwcap and Cork Closures on SO_2 Levels and Aromas in a Sauvignon Blanc Wine

MICHAEL BRAJKOVICH,† NIGEL TIBBITS,† GUILAINE PERON,§ CYNTHIA M. LUND,# STUART I. DYKES,§ PAUL A. KILMARTIN,§ AND LAURA NICOLAU*,§

Kumeu River Wines, P.O. Box 24, Kumeu, New Zealand; Wine Science Programme, The University of Auckland, Private Bag 92019, Auckland, New Zealand; and HortResearch, Mount Albert Research Centre, Private Bag 92169, Auckland, New Zealand

The development of a Sauvignon Blanc wine sealed under screwcap and cork was undertaken using different fill heights and initial levels of free SO_2 (20, 25, and 30 mg/L) over 2 years. More SO_2 was lost for wines under cork over the first 3 months, corresponding to a higher level of dissolved oxygen at bottling. From this time wines under cork and screwcap lost SO_2 at a similar rate and retained dissolved CO_2 equally well, indicating that both types of closure presented a similar effective barrier to gas movement. After 2 years in the bottle, the different treatments retained similar levels of the volatile thiols 3-mercaptohexyl acetate (3MHA) and 3-mercaptohexanol (3MH) responsible for fruity aromas, with initial SO_2 levels having no effect, but the thiol concentrations were 18−23% lower under cork, which may be due to absorption of volatiles into the cork. Levels of polyphenols such as caftaric acid and the absorbance at 420 nm were the same for wines under cork and screwcap, whereas some indication was given that more oxidation occurred with a lower level of initial free SO_2. Although the different treatments were not readily distinguished by a sensory panel, the data for individual wines showed a positive correlation between passion fruit descriptors and levels of 3MHA and 3MH.

KEYWORDS: Sauvignon Blanc; screwcap; cork; closure; wine aging; sensory analysis; polyphenols; volatile thiols

INTRODUCTION

Cylindrical corks have been the closure of choice in glass wine bottles for several centuries. However, winemakers have been led to seek alternatives due to a number of problems with cork, including taint arising from trichloroanisoles (TCA) (*1*) and natural variability in permeability to gases leading to sporadic bottle oxidation. A range of synthetic cylindrical closures are currently available (*2*), and although these eliminate the incidence of cork taint, other closure components can migrate into the wine over time, they are more permeable to oxygen, and plastic materials can absorb volatiles from the wine.

The screwcap closure, also known as the roll-on tamper-evident (ROTE) closure, creates an airtight seal around the rim of the bottle as opposed to the inner surface of the bottle neck. The inner liner of the screwcap typically consists of a 19 μm PVDC film in contact with the wine, a 20 μm layer of tin foil as a gas barrier, and a 2 mm polyethylene wad to maintain compression. Although screwcaps have been used commercially for over 30 years, their use with higher value wines stems from the bottling of 2000 Riesling by winemakers in Clare Valley, South Australia. Over a short period of time, winemakers in New Zealand have shifted from bottling practically none of their wines under screwcap to ∼70% of wines in 2005, largely through the efforts of the New Zealand Screwcap Wine Seal Initiative established in 2001 (*3*, *4*).

Few studies have been published in which comparisons have been made between wines under cork and screwcap. Trials conducted in Australia in the 1970s on the new Stelvin closures with red and white wines showed that wines under screwcap retained more sulfur dioxide after 18 months in the bottle than under cork and received higher quality scores (*5*, *6*). A major trial at the Australian Wine Research Institute on a Semillon wine from the Clare Valley has involved a comparison of 14 different closures, including natural corks and screwcaps (*7*). In this study the wine under screwcap recorded the lowest drop in SO_2 and ascorbic acid and the least browning (visible absorbance at 420 nm), all pointing to the lowest level of wine oxidation, whereas in sensory tests the screwcap wine was highest in overall fruit and lowest in developed and "oxidized" characters. However, after 18 months of bottle storage, a new negative aroma described as "reduced" or rubbery was noted and was observed to be most intense in the wine under screwcap. It was suggested that having a higher filling height and more

* Corresponding Author: telephone (64-9) 3737999 ext. 84265; fax (64-9) 3737422; E-mail l.nicolau@auckland.ac.nz.
† Kumeu River Wines.
§ The University of Auckland.
# HortResearch.

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Table 1. Levels of Dissolved Oxygen at Day 1 and SO_2 after 23 Months for the 12 Wine Treatments ($n = 4$)[a]

wine treatment	fill height, mm	target initial free SO_2, mg/L	DO at 1 day, mg/L	free SO_2 at 23 months, mg/L	total SO_2 at 23 months mg/L
1, screwcap	20	20	0.78 (±0.08)a	12.3 (±0.5)a	109 (±1)a
2, screwcap	25	20	0.63 (±0.11)a	11.8 (±1.0)a	108 (±1)a
3, screwcap	30	20	0.63 (±0.13)a	10.8 (±0.5)ab	107 (±1)ab
4, cork	10	20	1.33 (±0.34)b	9.0 (±1.4)b	104 (±3)b
5, screwcap	20	25	0.59 (±0.06)a	14.5 (±1.3)c	115 (±1)c
6, screwcap	25	25	0.61 (±0.06)a	14.0 (±0)ac	114 (±1)c
7, screwcap	30	25	0.66 (±0.03)a	13.5 (±0.6)ac	113 (±1)c
8, cork	10	25	1.10 (±0.25)b	11.8 (±1.7)a	108 (±5)a
9, screwcap	20	30	0.63 (±0.10)a	17.3 (±0.5)d	118 (±1)d
10, screwcap	25	30	0.62 (±0.02)a	16.3 (±0.5)cd	118 (±1)cd
11, screwcap	30	30	0.66 (±0.08)a	14.0 (±0)ac	115 (±1)cd
12, cork	10	30	1.14 (±0.36)b	12.3 (±3.3)a	112 (±3)ac

[a] Standard deviations are given in parentheses after each value. Values followed by different letters are statistically different (ANOVA, Fisher's $LSD_{0.05}$).

oxygen at bottling, or using a treatment to remove sulfides prior to bottling, may have avoided the occurrence of this flavor attribute (*7*).

This study was initiated by the New Zealand Screwcap Initiative to provide practical guidelines for bottling wines under screwcap. Most wineries use free SO_2 in the order of 25−30 mg/L for wines bottled under cork, but with the prospect of less oxygen ingress under screwcap, many were considering using slightly less free SO_2 at bottling. In this trial, a 2002 Marlborough Sauvignon Blanc, a leading white wine from New Zealand, was bottled under cork and screwcaps with three different fill heights (20, 25, and 30 mm) and treated with three initial levels of free SO_2 (20, 25, and 30 mg/L). The decline in SO_2 levels was monitored 4, 10, and 23 months after bottling; at 23 months samples were also taken for further chemical and sensory analysis of parameters related to Sauvignon Blanc aroma and wine oxidation (*8*−*10*).

MATERIALS AND METHODS

Sauvignon Blanc grapes were mechanically harvested in Marlborough, New Zealand, at 22.8 °Brix, titratable acidity of 8.7 g/L, and pH of 3.12. After crushing and destemming, the free run juice coming from a pneumatic press was fermented with Prise de Mousse yeast (Lalvin EC1118) at a temperature of 10−13 °C for ~3 weeks at Foxes Island Wines, using standard Marlborough winemaking techniques. Bentonite was added during fermentation, but there were no ascorbic acid additions and no oak contact. The wine was bottled at Kumeu River Wines, Auckland, on October 17, 2002, at which point it had a titratable acidity of 7.9 g/L, a pH of 3.22, an alcohol content of 13.0%, and a residual sugar level of 4.5 g/L. The wine was filtered through Sietz SD100 lenticular filters and a 0.65 μm membrane filter prior to bottling. The wine was separated into three 167 L lots, and sulfur dioxide was added to target levels of 20, 25, and 30 mg/L free SO_2. The wine was bottled under cork (44 × 24 mm, super grade, hydrogen peroxide treated) at a single fill height of 10 mm (being the distance from the bottom of the cork to the liquid level at bottling), and under Stelvin brand screwcap with Saran−tin liners (Esvin Wine Resources, Auckland, New Zealand) at fill heights of 20, 25, and 30 mm (the distance from the rim of the bottle or screwcap liner to the liquid level). Forty-eight bottles of each of 12 wine treatments (**Table 1**) were numbered and randomly stored within treatments in an underground concrete cellar with a temperature of 6−14 °C and a relative humidity of ~80%. The screwcap-sealed bottles were stored upright, and the cork-sealed bottles were stored lying down.

Dissolved Oxygen (DO) and Carbon Dioxide. Measures of DO were made using an Orbisphere 3650 meter on four bottles of each wine treatment. Immediately after the bottles were opened, 250−300 mL of wine was pumped through the Orbisphere meter using a peristaltic pump. A further probe and second Orbisphere meter were used in series alongside the DO meter to measure levels of dissolved CO_2.

Sulfur Dioxide. Levels of free and total SO_2 were determined for four bottles of each treatment using the aspiration method (*11*).

For three of the treatments (3, screwcap, 30 mm fill height, and 20 mg/L initial free SO_2; 11, screwcap, 30 mm fill height, and 30 mg/L initial free SO_2; 12, cork, 30 mm fill height, and 30 mg/L initial free SO_2) the following chemical and sensory analyses were undertaken in triplicate once the wines had been in the bottle for 2 years. Three bottles from each treatment were split into six 375 mL bottles under nitrogen and stored at 4 °C. Within 7 days wines from the same bottles were used for both chemical and descriptive sensory analyses. Wine from new bottles were used for difference sensory testing, which was conducted in the same week as the descriptive analysis.

Volatile Thiols. The method of Tominaga et al. was used to determine the level of 3-mercaptohexyl acetate (3MHA) and 3-mercaptohexan-1-ol (3MH) (*9*), using 4-methoxy-2-methyl-2-mercaptobutane as an internal standard. The thiols were extracted from the wine using *p*-hydroxymercuribenzoic acid, which was then fixed onto an anion exchange column before the thiols were eluted with cysteine and extracted into dichloromethane prior to concentration and manual injection of 4 μL onto an Agilent 6890N GC with an Agilent 5973 MS detector. The thiols were separated on a 50 m BP20 capillary column (220 × 0.25 μm) using He carrier gas at 28 cm/s and an oven temperature ramping from 40 to 220 °C for a 71 min run. Standard curves were obtained by adding increasing quantities of the two volatile thiols to a Sauvignon Blanc wine (50−500 ng/L of 3MHA; 500−5000 ng/L of 3MH). The correlation coefficient (R^2) was 0.990 for 3MHA and 0.997 for 3MH. The reproducibility of the method was evaluated by repeating the analysis of the same Sauvignon Blanc wine six times under constant operating conditions. Relative standard deviations of 6 and 5% were obtained for 3MHA and 3MH, respectively.

Visible Absorbance. The absorbance at 420 nm was measured on a Cary 50 UV spectophotometer and was used to indicate the degree of brown color of the wine (*12*).

HPLC Analysis. Monomeric wine polyphenols were determined using an HPLC method previously outlined (*13*). In brief, 20 μL of filtered wine was injected onto a Phenomenex Luna C18 column (4.6 × 250 mm, 5 μm particle size) on an Agilent 1100 series instrument with a diode array detector set at 280 nm (for flavan-3-ols), 320 nm (for hydroxycinnamic acids), and 365 nm (for flavonols). A ternary solvent was run over 2 h employing water, 5% aqueous acetic acid, and acetonitrile. The main polyphenols targeted were caftaric acid (the hydroxycinnamic acid present in highest levels) and *S*-glutathionyl caftaric acid (known to form during the enzymic oxidation of caftaric acid in crushed grapes in the presence of glutathione).

Sensory Analysis. Twelve trained panelists performed the sensory evaluation of the wine in booths with daylight lighting at the HortResearch Sensory and Consumer Science Facility in Mount Albert, Auckland, New Zealand. The panelists were trained for 50 h using traditional sensory methodology to evaluate Sauvignon Blanc. A positive airflow was maintained in the booths to reduce any odors not associated with the wine. Three-digit codes were put on the wine glasses to remove any identification of samples. Approximately 20 mL of wine was presented in standard XL wine glasses with watch glass lids. Wine was served at room temperature (20 °C). Panelists used double-filtered (Microlene) water and crackers as a palate cleanser.

The panelists assessed the wines with an *R*-index difference test. Coded samples were presented in a balanced design of pairs for each of the four possible combinations of wines, which for three wine treatments yielded a total of 24 wine samples (AA, AB, BA, BB; AA, AC, CA, CC; BB, BC, CB, CC). The panelists were asked whether the wine pairs were "different" or the "same", and if their judgment was "sure" or "unsure". *R*-index values (R_i) were calculated, and R_i-50% results were compared to the critical value for a two-tailed test at a level of significance of 5% that the result is greater than chance, that is, a critical value of 18.9% for $N = 24$ (*14*, *15*).

The panelists also provided a sensory profile of the three treatments of wines using attributes developed by the panel to describe New

Zealand Sauvignon Blanc wines. The panelists also supplied further descriptors of the wines to lessen the "dumping effect" (incorrectly assigning a "new" attribute to one of the small number of descriptors available), but were not asked to look specifically for "reduced" or rubbery odors. Triplicate samples were presented monadically in a balanced design (i.e., each panelist described the wine from nine different bottles). The descriptors and their reference compounds were as follows: sweet-sweaty-passion fruit (3MHA), passion fruit skin-stalk (3MH), capsicum (isobutyl-methoxypyrazine), cat urine (4-mercapto-4-methylpentan-2-one), grassy (*cis*-hexan-1-ol), and lemon peel (1 cm^2 of a Yen Ben cultivar). The panelists used an unstructured 150 mm line scale to rate the intensities of each attribute.

The results were analyzed using a two-factor (wine and panelist) analysis of variance. For each sensory descriptor p values were determined to see if a level of significance of 5% had been achieved. A principal component analysis (PCA) was undertaken using The Unscambler (v 9.1a, CAMO Process AS) to associate the six sensory descriptors and six chemical components as active variables for the nine different bottles of wine. All of the descriptors were normalized using the correlation matrix for the analysis.

The various chemical analyses are reported plus or minus the standard deviation of the results. Statistical analyses of the chemical data were also undertaken using ANOVA single factor (Microsoft Excel, 2002) and Fisher's least significant difference ($LSD_{0.05}$).

RESULTS AND DISCUSSION

The day after the wine was bottled, levels of DO were found to be in the range of 0.5−0.9 mg/L for the screwcap-sealed wines, whereas significantly higher and more variable levels of 0.8−1.6 mg/L were seen with the cork seals (**Table 1**). The bottling machine did not have pre-evacuation or inert gas sparging, so the DO level was influenced by the flow geometry of each filling head, which will differ to some extent. On the other hand, the corking head did have a vacuum facility, but the DO readings on the subsequent day showed that this was quite variable in efficiency. This meant that the cork could act as a piston to compress air into the wine in a variable manner, leading to higher DO values than for the screwcap-sealed wines. Oxygen included within the mass of the dry cork may also diffuse into the wine, particularly during the initial weeks of storage (*16*). After 4 and 10 months in the bottle, when four bottles of each treatment were again sampled, all DO readings were below 0.01 mg/L and were equally low under cork as under screwcap.

Levels of CO_2 were similar across the 12 treatments the day after bottling, and the wines sealed with cork recorded 96 ± 4% of the overall average CO_2 value. With subsequent testing, the CO_2 readings, in the range of 0.7−1.0 g/L, were again very uniform across treatments, and after 4 months in the bottle, the cork-sealed wines averaged 95 ± 3% of the average value; again, after 10 months in the bottle, cork maintained 96 ± 5% of the overall average CO_2 reading. These results indicate that cork was acting as an effective gas barrier, with similar gas retention to the screwcap seal.

Changes in total SO_2 levels are a good indicator of the occurrence of oxidation in wine (*7*). The initial levels of SO_2 in the 167 L wine lots for each of the target levels were as follows: for a target level of 20 mg/L, measured levels of 22 mg/L free and 126 mg/L total SO_2 were obtained; for a target of 25 mg/L, 26 mg/L free and 131 mg/L total; and for a target of 30 mg/L, 31 mg/L free and 136 mg/L total SO_2. The decline in total SO_2 over the first 4 months in the bottle was greatest with cork (12 ± 2% average loss compared to 9 ± 1% for screwcaps) (**Figure 1**), consistent with the higher initial DO levels. For wines under screwcap more SO_2 was lost with a larger initial headspace volume. One of the bottles under cork

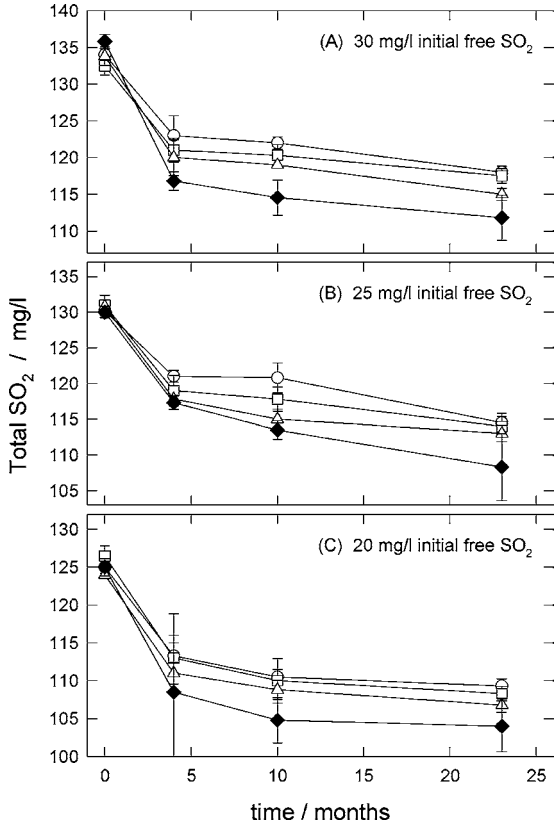

Figure 1. Decrease in levels of total SO_2 for Sauvignon Blanc wines bottled initially with (**A**) 30 mg/L free SO_2, (**B**) 20 mg/L free SO_2, and (**C**) 20 mg/L free SO_2: (○) screwcaps, 20 mm fill height; (□) screwcaps, 25 mm fill height; (△) screwcaps, 30 mm fill height; (◆) corks, 10 mm fill height (n = 4). Error bars are given for the standard deviation in each value.

produced a much lower value of 93 mg/L, giving rise to the large error bars for this point in **Figure 1C**. Although some bottles under cork in the trial were a few milligrams per liter lower than the average, this was the only example of what may be described as sporadic bottle oxidation. From 4 to 10 months in the bottle, the wines under cork lost a further average 2.9 ± 0.8% total SO_2 (1.4 ± 0.9% for screwcaps), whereas from 10 to 23 months cork (2.6 ± 1.9%) and screwcap (2.6 ± 1.3%) wines recorded the same drop in total SO_2 to reach the values given in **Table 1**. During the 10−23 month period, the decline in SO_2 is no longer expected to be due to oxygen present at bottling, but rather to a similar small ingress of oxygen past the liner of the screwcap or through the cork closure.

Losses of free SO_2 followed a similar trend (**Figure 2**), with a large decrease over the first 4 months of 48 ± 5% on average for corks (versus 28 ± 5% for screwcaps) due largely to oxygen present at bottling. After this time, the decreases were similar with a further 14 ± 4% loss from 4 to 10 months for corks (versus 15 ± 10% for screwcaps) and 15 ± 4% from 10 to 23 months for corks (versus 14 ± 4% for screwcaps). Some bottles fell below 10 mg/L after 23 months, which may be of concern for continued aging of these wines. We can again conclude that with cork and screwcap the rate of ingress of oxygen into the bottle during storage was small. This is consistent with recent reports that the oxygen permeability of the best corks is of a similarly low value to that of screwcaps of <0.001 mL of oxygen per day (*17*). The role of this low level of oxygen in wine development in the bottle is still a matter of some debate.

Sauvignon Blanc wine contains a number of volatile thiols, present at very low concentrations, which are nevertheless

Table 2. Levels of Volatile Thiols, Visible Absorbance at 420 nm, and Levels of Polyphenols Analyzed by HPLC after 2 Years for Three of the Wine Treatments ($n = 3$)[a]

wine treatment	3, screwcap	11, screwcap	12, cork
initial free SO_2, mg/L	20	30	30
free SO_2 at 23 months, mg/L	10.8 (±0.5)a	14.0 (±0)a	12.3 (±3.3)a
3MHA, ng/L	117 (±9)a	122 (±14)a	93 (±11)a
3MH, ng/L	2188 (±109)a	2270 (±98)a	1873 (±81)b
visible absorbance at 420 nm	0.079 (±0.001)a	0.076 (±0.001)a	0.077 (±0.003)a
epicatechin, mg/L	5.8 (±0.2)a	6.6 (±0.1)b	6.6 (±0.1)b
caftaric acid, mg/L (CAE)	16.9 (±0.1)a	17.6 (±0.1)b	17.5 (±0.1)b
S-glut-caftaric acid, mg/L (CAE)[b]	7.6 (±1.1)a	6.1 (±0.1)a	6.2 (±0.1)a

[a] Standard deviations are given in parentheses after each value. Values followed by different letters are statistically different (ANOVA, Fisher's $LSD_{0.05}$). [b] CAE = caffeic acid equivalents.

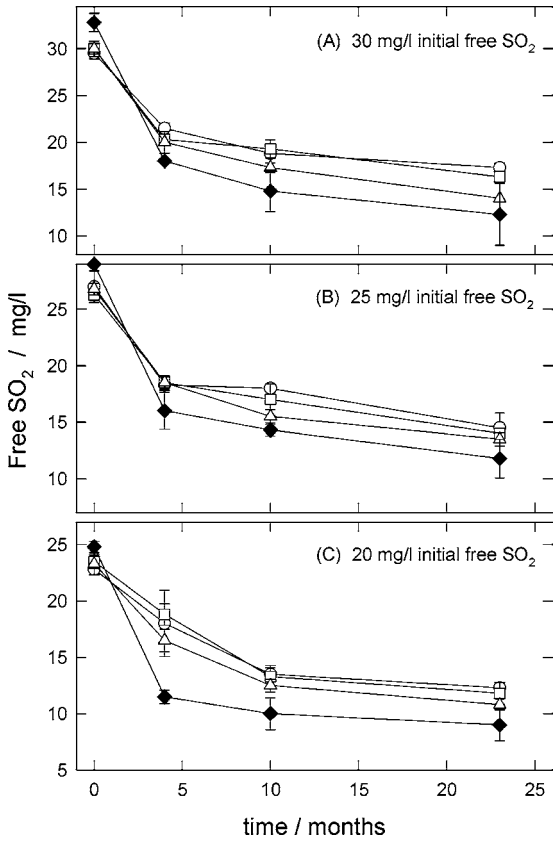

Figure 2. Decrease in levels of free SO_2 for Sauvignon Blanc wines bottled initially with (**A**) 30 mg/L free SO_2, (**B**) 20 mg/L free SO_2, and (**C**) 20 mg/L free SO_2: (○) screwcaps, 20 mm fill height; (□) screwcaps, 25 mm fill height; (△) screwcaps, 30 mm fill height; (◆) corks, 10 mm fill height ($n = 4$). Error bars are given for the standard deviation in each value.

responsible for a number of distinctive varietal aromas (8). These include 3MHA, giving a box tree or passion fruit aroma, and 3MH, giving a fruity, grapefruit aroma (*9*). Both of these thiols degrade with age in the bottle, particularly 3MHA, which also hydrolyzes to release 3MH (*8*), and via oxidation in the presence of polyphenols or when levels of protective SO_2 are low (*10*). The level of the volatile thiols 3MHA and 3MH after 2 years in the bottle for treatments 3, 11, and 12 are shown in **Table 2**. The levels of 3MHA and 3MH are well above the perception threshold for these components, being 4 ng/L for 3MHA and 60 ng/L for 3MH (*9*). The level of volatile thiols in the bottles with cork were 18−23% lower than for the screwcap bottles with the same initial level of SO_2. On the other hand, the difference between the two screwcap wines with different SO_2 levels was not statistically significant. The higher initial level of DO in the wines under cork may have contributed to the greater drop in 3MHA and 3MH, but the SO_2 data and results presented below for changes in levels of polyphenols and 420 nm absorbance do not indicate that oxidation was greater for the wine under cork. The possibility that the cork closure absorbed a certain percentage of 3MHA and 3MH during bottle storage needs to be considered here (*18*).

The visible absorbance at 420 nm and levels of catechol-containing polyphenols were quite similar across the three treatments tested (**Table 2**). Free caffeic acid, catechin, and flavonols such as quercetin and its glycosides were all below measurable levels. In particular, the screwcap- and cork-sealed wines with the same initial SO_2 level of 30 mg/L gave nearly identical results. The screwcap wine with the lower 20 mg/L initial free SO_2 gave a slightly higher 420 nm absorbance and was 4% lower in caftaric acid, lower in epicatechin, and, in two of the three wines tested, higher in *S*-glutathionyl caftaric acid. These indicators suggest that the level of SO_2 was more important for wine oxidation than the choice of cork or screwcap to seal the wines.

The sensory panel was first asked to evaluate whether pairs of wines were "different" or the "same". There was not a significant difference according to the *R*-index calculation. Although the panel identified different wines correctly 64% of the time, the answers were correct only 50% of the time when the wines were the same. Although a low test power is obtained by using only 12 assessors in the difference test, the lack of a significant difference between the treatments was supported by the following results of the descriptive analysis.

The average intensities of sensory descriptors for the three wines are presented in **Figure 3**. Aromas such as passion fruit associated with the volatile thiols 3MHA and 3MH were strong in the wines. The panelists also described the wines as containing citrus, stone fruit, and tomato vine characters, but they did not note a burnt or rubbery smell in any of the wines. Likewise, none of the wines sealed with cork were noted to be suffering from cork taint [which had been seen on occasions in other tastings of wines from this trial (*17*)]. On the other hand, the average intensities of the six sensory descriptors were very similar for the three wines (**Figure 3**), and in each case the statistical analysis produced p values >0.05. Differences between judges in the scale of intensities ascribed to the descriptors had lower p values. Once again, the small difference in levels of volatile thiols (**Table 2**) was not large enough to permit a sensory differentiation of the wines.

The PCA did not reveal any extreme values in the sensory or chemical data, whereas some grouping of the wine treatments was evident (**Figure 4**). The sensory descriptors (active variables) were dispersed around the four quadrants of the projection, whereas the first two principal components explained 58% of the variability in the model. Principal component 1

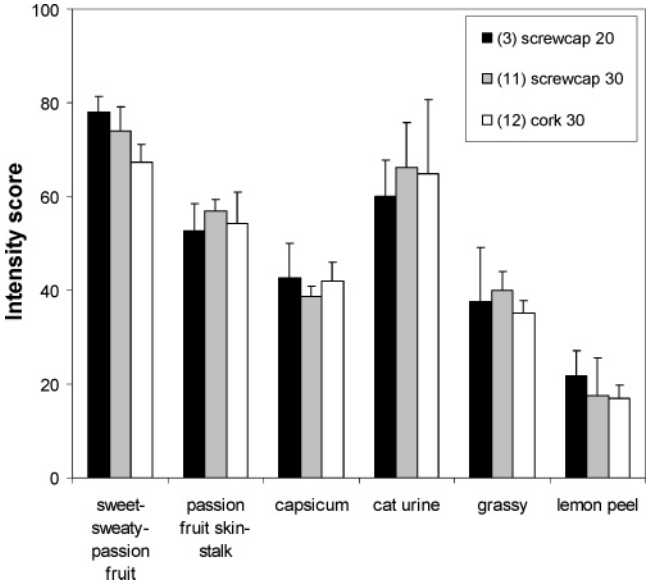

Figure 3. Intensity scores for six descriptors given by 12 panelists for three of the Sauvignon Blanc wine treatments: (black bars, 3) screwcap with 20 mg/L free SO_2; (gray bars, 11) screwcap with 30 mg/L free SO_2; (white bars, 12) cork with 30 mg/L free SO_2. Error bars are given for the standard deviation in each value.

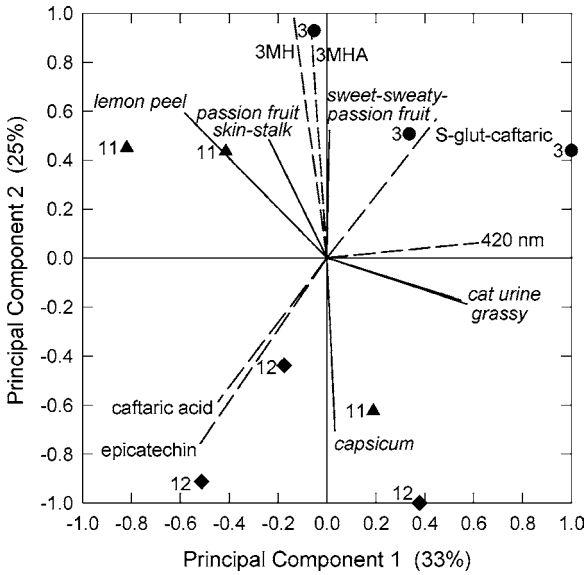

Figure 4. PCA biplot for the first two principal components for six sensory descriptors (solid lines) and six chemical measures (dashed lines) for nine individual Sauvignon Blanc wine bottles from three treatments: (3) screwcap with 20 mg/L free SO_2; (11) screwcap with 30 mg/L free SO_2; (12) cork with 30 mg/L free SO_2.

appears to comprise predominantly phenolic attributes, with caftaric acid and epicatechin showing covariance and correlating negatively with *S*-glutathionyl caftaric acid and with the absorbance at 420 nm to some extent. Grassy and cat urine sensory attributes also strongly covary and contribute to the first principal component. Levels of 3MHA and 3MH positively covary and load primarily on principal component 2. The sensory attributes of "sweet-sweaty-passion fruit" and "passion fruit skin-stalk" also correlate with levels of 3MHA and 3MH, whereas "capsicum" correlates negatively with all of these on the second principal component. Although levels of methoxypyrazines were not measured in this study, they are known to be particularly stable in wine (*19*), and significant differences in levels between these wines would not be expected. Hence, the negative correlation of capsicum with 3MHA and 3MH is likely to be due to the dampening of perceived capsicum with higher fruity aromas. Principal component 3 (not shown) accounts for 22% of the total variance and largely confirms the interpretation made above with the "sweet-sweaty passion fruit" vector correlating strongly with the 3MH and 3MHA attributes. However, the "passion fruit skin-stalk" vector loads 166° relative to the "sweet-sweaty passion fruit" vector in this component, implying a significant negative correlation.

The 20 mg/L free SO_2 screwcap wines (treatment 3) and the wines sealed under cork (treatment 12) tended toward opposite sides of the biplot (**Figure 4**). The lower levels of 3MHA and 3MH seen in wines under cork largely explains this trend. On the other hand, the influence of small levels of cork taint in lowering the perception of passion fruit related aromas, while not being perceived overtly as a cork taint, remains a possibility.

In conclusion, the extents of oxygen ingress, given by losses of SO_2, for wines bottled under cork and screwcap were shown to be very similar for the Sauvignon Blanc wine used in this trial. The difference between treatments in terms of the loss of SO_2 in the first 10 months after bottling appeared rather to be due to the differing exposure to oxygen at the time of bottling. Whereas the wines under cork and screwcap were not seen as different by a sensory panel, more of the volatile thiols 3MHA and 3MH were lost under cork than under screwcap (by 18−23%), and this loss could be due either to the absorption of aromas by cork or to wine oxidation.

In further trials we intend to follow the development of volatile thiols and other aroma compounds right from the time of bottling. Associations between sensory descriptors and chemical analyses will be extended to a wider range of Sauvignon Blanc wines. More work is also required to determine the optimal or minimum levels of SO_2 required to maintain varietal aromas in wines such as Sauvignon Blanc for an extended period of time.

ABBREVIATIONS USED

HPLC, high-pressure liquid chromatography; GC-MS, gas chromatography with mass spectrometer detection; DO, dissolved oxygen; 3MH, 3-mercaptohexan-1-ol; 3MHA, 3-mercaptohexyl acetate; ROTE, roll-on tamper-evident; TCA, trichloroanisoles; PVDC, polyvinylidene chloride; R_i, *R*-index values; *N*, number of decisions used to obtain the *R*-index; PCA, principal component analysis.

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This trial was undertaken by the New Zealand Screwcap Wine Seal Initiative. The wine was made by John Belsham at Foxes Island Wines, Marlborough, New Zealand. The screwcaps were donated by Esvin Wine Resources and the bottles by ACI Glass Packaging, New Zealand. Orbisphere meters were kindly loaned from the Nobilo Wine Group winery at Huapai, Auckland.

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