Technical notes

Metals in Australian wine

Metals are a fundamental component of wines and all naturally occurring metals can be found at some level in wine. Metals find their way into wine in a variety of ways:

- from the soils the vines are grown in and the water the vines consume
- in the fertilisers and sprays that help vines grow and protect them from pests
- through contact with processing equipment and storage vessels
- occasionally by deliberate addition, such as additions of copper sulfate made to address sulfidic aromas.

Some metals, such as copper, iron, zinc and aluminium, can have long-term impacts on the flavour, aroma and shelf life of wine, as they play important roles in the chemical processes that take place as wine matures. Other metals are essential nutrients for yeast and therefore contribute to healthy fermentations. There are also regulatory limits for a number of metals in some of Australia's export markets. Given these important roles for metals in wines, it is useful to understand their typical levels and likely sources.

Metals survey

AWRI Commercial Services conducts periodic surveys of data from wines submitted for metals analysis. This article presents aggregated data from more than 1,200 Australian wines analysed from October 2016 to September 2017. The samples include only finished commercially produced wines, 55% red and 45% white, with sparkling and fortified wines excluded. Metals were analysed using inductively coupled plasma mass spectrometry at the AWRI's NATA ISO 17025 accredited laboratory. The specific elements examined include aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), lithium (Li), manganese (Mn), nickel (Ni), palladium (Pd), platinum (Pt), selenium (Se), silver (Ag), strontium (Sr), tin (Sn), vanadium(V) and zinc (Zn). Potassium (K), sodium (Na), calcium (Ca) and magnesium (Mg) were also measured – these are typically found in wine at higher concentrations than the other metals listed. This article focuses on the metals found at trace levels; however, the full dataset is available on the AWRI website at https://www.awri.com.au/wp-content/uploads/2018/04/trace_metals_data2018.pdf. It should also be noted that although selenium is not a metal, its important role as a nutrient means it is commonly measured with the trace metals – as such, it is included here.

Table 1 presents a summary of the metal concentrations measured in the sample set.

Table 1. Concentrations of trace metals in a set of commercially produced red and white wines. All results are presented in μg/L (parts per billion, ppb).

	Wine type	No. of samples	Mean	Standard deviation	Minimum	Median	Maximum	International limits[a]
Aluminium#	red	703	302.7	269.7	17	215	2330.6	8,000
	white	570	697.6	595.7	5	531	4909	
Arsenic #	red	703	2.4427	2.3617	1*	2	20.2	100-500
	white	571	3.799	3.576	1*	3.1	33.8	
Cadmium	red	703	1.0357	0.2816	1*	1	3.7	10-1,000
	white	571	1.0322	0.3431	1*	1	6.5	
Chromium#	red	703	13.361	6.555	1*	13	73	-
	white	570	9.691	7.411	1*	8.1	67	
Cobalt #	red	703	4.461	2.997	1*	3.9	32.9	20
	white	570	3.464	2.3378	1*	3.3	21.9	
Copper#	red	705	266.2	312.5	50*	200	4,100	1,000-10,000
	white	577	338.6	893.6	50*	100	9,500	
Iron#	red	705	1657.1	852.5	150*	1,500	7,520	8,000-20,000
	white	576	950.3	1,055.5	150*	700	12,400	
Lead#	red	702	3.713	5.909	1*	2.6	99.5	150-300
	white	563	10.151	11.026	1*	8.6	124.1	
Lithium#	red	703	10.533	7.506	2.5*	8.8	59.6	-
	white	570	8.896	6.095	2.5*	8.3	32.5	
Manganese#	red	705	144.66	641.5	150*	1,300	5,700	-[b]
	white	577	960.8	640	150*	900	8,100	
Nickel	red	703	14.346	12.976	1*	12.8	311.3	-
	white	569	13.843	11.921	1*	11.4	95.7	
Palladium	red	703	1.4211	1.4092	1*	1	17.9	-
	white	571	1.5794	1.666	1*	1	15.1	
Platinum	red	703	1.0043	0.0652	1*	1	2	-
	white	571	1.0018	0.0418	1*	1	2	
Selenium	red	703	1.7913	2.402	1*	1	27	1,000
	white	570	1.541	0.3011	1*	1	21.1	
Silver	red	697	1.0363	0.0419	1*	1	5.0	500
	white	569	1.0018	2.3357	1*	1	2.0	
Strontium#	red	703	1565.4	680.9	118	1468	4,717	-
	white	571	830.1	602	1*	680	3,754	
Tin#	red	703	2.847	3.036	1*	2	30.5	1,000-250,000
	white	570	4.587	11.868	1*	2.55	200	
Vanadium	red	703	4.77	10.936	1*	1	84.9	-
	white	570	4.833	10.969	1*	1	135.4	
Zinc#	red	703	993.7	435.9	35	979	4,089.9	5,000-40,000
	white	571	782.7	598.5	2.5*	731.4	9,333	

Notes: Values marked with * are at the limit of detection (LOD) for the analytical method. Elements marked with # show a significant difference between the mean values for red and white wines (95% confidence level, one-way analysis of variance). [a]International limits shown are sourced from the *Analytical requirements for the export of Australian wine* page on the AWRI website as at March 2018. [b]Until recently, China imposed a limit of 2,000 μg/L for manganese in wine, but that limit has now been removed.

General observations

The first important observation from the dataset is that none of the concentrations observed approach levels that are of concern to human health. As stated earlier, all naturally occurring metals can be found in wine at some level and their presence in this table simply reflects this fact. The concentrations are consistent with those found in studies of wines from across the world. Similar background levels of these metals are also found in all foods, beverages and drinking waters worldwide.

All of the wines analysed also meet Australian regulatory requirements for metal concentrations in wine. In relation to international limits (which vary across different jurisdictions), Cu, Co, Fe and Zn were the only metals for which some samples exceeded the published limits. In the case of copper, Australian wine exporters are aware of the lower limits imposed in certain markets and ensure that they manage copper additions accordingly. Some of the outlying values for cobalt, iron and zinc are close to or exceed the limits for some markets and this emphasises the need to monitor both the levels of trace metals in wine and the changing regulatory requirements of export markets. It should be noted, however, that the vast majority of wines in this dataset have metal concentrations below the limits for all export markets.

Differences between red and white wines

Looking more closely at the data, it becomes evident that some elements are much more dependent on wine type (i.e. red vs white) than others. For example, nickel shows very little difference in the distribution of results between red and white wines (Figure 1). By comparison, in the equivalent plot for manganese (Figure 2), a distinct difference can be seen.

Statistical analysis (using one-way analysis of variance) of the means for each of these metals confirms this, with no significant difference found between average Ni content for red and white wines, but a statistically significant difference identified between red and white wines for mean Mn levels. No significant differences between red and white wines were also found for Cd, Pd, Pt, Se, Ag and Va. It is not possible to determine from the available data if this lack of difference is due to the relatively low levels of these metals in the wines or because the primary source of these metals is due to a processing input common to both red and white winemaking, such as storage in stainless steel tanks. Significant differences in concentrations between red and white wines were found for Al, As, Cr, Co, Cu, Fe, Pb, Li, Mn, Sr, Sn and Zn, as well as K, Na, Ca and Mg. More detail of the statistical analysis and distribution graphs for other metals can be found in the full data set available online.

For Cr, Co, Fe, Li, Mn, Sr and Zn the mean value in red wines is higher than that in white wines. This is, within reason, expected, as many metals accumulate in the skins of grapes and during the red winemaking process there is greater opportunity for their extraction into the final wine than in white winemaking where skin contact is limited.

This trend is, however, reversed for Al, As, Cu, Pb and Sn where the means (and the medians with the exception of Cu) are higher for white wines than red wines. In the case of copper, this result is unlikely to be particularly significant because of the way copper is added to wines on

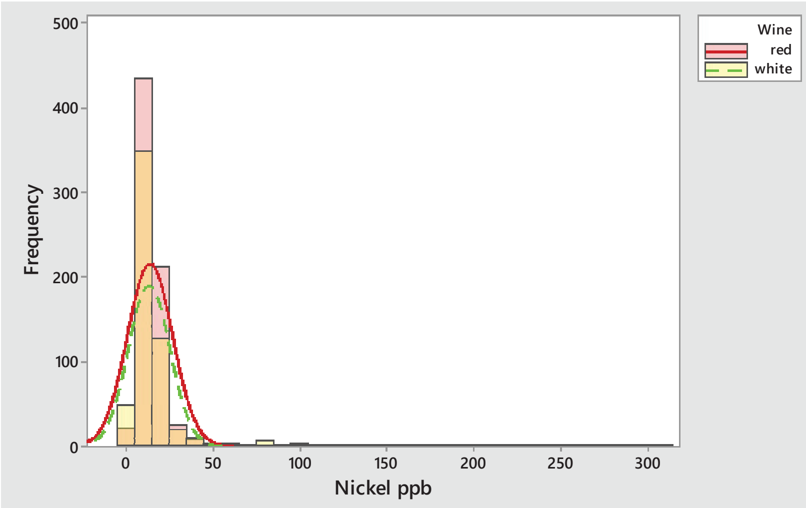

Figure 1. The distribution of nickel levels in the red and white wines analysed.

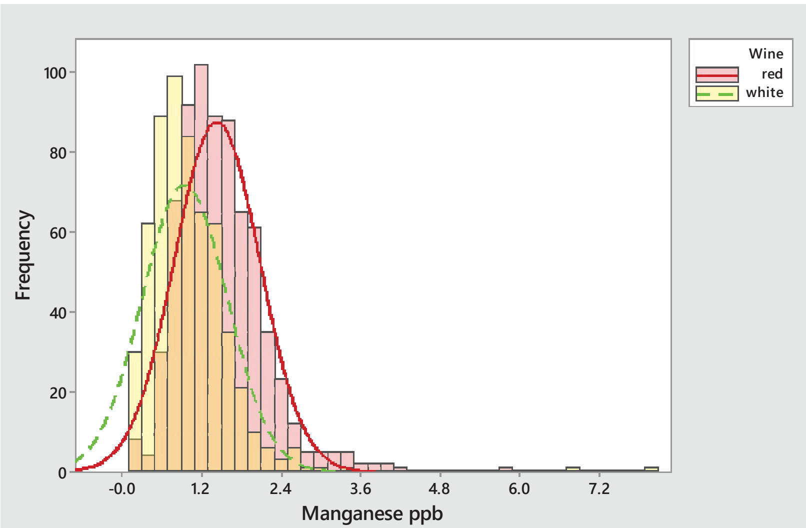

Figure 2. The distribution of manganese levels in the red and white wines analysed.

an ‘as needed’ basis to treat sulfidic characters. For Sn, the median values are quite close to the limit of detection for the analysis and so the difference may be simply an analytical artefact. For Al, As and Pb, however, there is a strong possible link to bentonite, which is commonly used in the production of white wines and rarely used in red wines. Recent benchmarking work conducted at the AWRI (to be featured in a future article) showed that the use of some bentonites did indeed significantly increase the levels of these metals in wines.

Understanding metal concentrations and limits

This article provides a snapshot of the typical levels of trace metals in Australian wines. It also highlights the importance of understanding the processes which can contribute to the metal content of wine when interpreting this type of data.

This is particularly relevant to the regulatory limits imposed for metal content (and other components) around the world. These should be based on sound scientific knowledge, including surveys such as this one, and should not become simply an exercise in ‘chasing zero’ if there is no reason to do so.

Research may be needed to give winemakers additional tools to influence the metal content of their wines. This would allow them to exert greater control over wine sensory development over time, influence shelf life and export their wines confidently around the world.

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