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Relationship between Red Wine Grades and Phenolics. 1. Tannin and Total Phenolics Concentrations

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Measuring chemical composition is a common approach to support decisions about allocating foods and beverages to grades related to market value. Red wine is a particularly complex beverage, and multiple compositional attributes are needed to account for its sensory properties, including measurement of key phenolic components such as anthocyanins, total phenolics, and tannin, which are related to color and astringency. Color has been shown to relate positively to red wine grade; however, little research has been presented that explores the relationship between astringency-related components such as total phenolic or tannin concentration and wine grade. The aim of this research has been to investigate the relationship between the wine grade allocations of commercial wineries and total phenolic and tannin concentrations, respectively, in Australian Shiraz and Cabernet Sauvignon wines. Total phenolic and tannin concentrations were determined using the methyl cellulose precipitable (MCP) tannin assay and then compared to wine grade allocations made by winemaker panels during the companies' postvintage allocation process. Data were collected from wines produced by one Australian wine company over the 2005, 2006, and 2007 vintages and by a further two companies in 2007 (total wines = 1643). Statistical analysis revealed a positive trend toward higher wine grade allocation and wines that had higher concentrations of both total phenolics and tannin, respectively. This research demonstrates that for these companies, in general, Cabernet Sauvignon and Shiraz wines allocated to higher market value grades have higher total phenolics and higher tannin concentrations and suggests that these compositional parameters should be considered in the development of future multiparameter decision support systems for relevant commercial red wine grading processes. In addition, both tannin and total phenolics would ideally be included because although, in general, a positive relationship exists between the two parameters, this relationship does not hold for all wine styles.

KEYWORDS: Red wine; grading; quality; tannin; total phenolics

INTRODUCTION

The allocation of food and beverage products to grades related to their value to a consumer is an integral part of the commercial production process. Perceptions of value can be influenced by many factors, but the sensorial effects elicited by the physical and chemical composition of the food or beverage play a strong role. Given that foods and beverages are composed of multiple components, it follows that the components themselves can, variably, influence the allocation of foods and beverages to various grades. For many foods and beverages, significant amounts of research have been conducted into better understanding which chemical components influence sensory attributes and market value or quality. Measuring these chemical components can increase our understanding of the sensory properties and support the process used to allocate foods and beverages to commercially relevant grade categories. Food and beverage quality is often described as a multivariate phenomenon (*1*, *2*), and in many areas of food science quality grading systems have been described that use an index of parameters, weighted variably depending on the product or market (*3*−*7*).

Wine represents a complex matrix of chemical components, derived from grapes and yeast. Grape composition clearly affects final wine composition, and many of the influences on grape composition have been discussed previously (*8*, *9*). Although the sensorial role of many chemical components in wine has been studied (*10*, *11*), significant further research is required to fully understand the relationship between wine composition and flavor. Red wine is a particularly complex beverage with compounds from multiple chemical classes contributing to its sensory properties, and the role of various compositional parameters in relation to wine quality has been discussed previously (*12*). However, defining the value, or quality, of foods and beverages can be challenging, and quality definitions vary depending on the perspective (*13*). The International Organization for Standardization of quality in foods and beverages defines quality as "the ability of a set of inherent characteristics of a product, system or process to fulfill the requirements of customers and other interested

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Table 1. Parameters Used To Investigate Relationships between Grape or Wine Composition and Red Wine Quality

variety	parameter	quality measure	reference
SHZ, CAS	wine color	20-point scale	*23*
multiple	wine color	sensory panel	*20*
multiple	Brix/acid ratio	sensory panel	*43*
multiple	multiple (environment and management)	multiple	*8*
SHZ, CAS	multiple	sensory panel	*30*
SHZ	multiple	20-point scale	*27*
CAS	partial defoliation	sensory panel	*44*
SHZ	glycosyl glucose and color	20-point scale and sensory panel	*45*
multiple	climate (Bordeaux)	wine vintage quality ratings (1−7 scale)	*46*
multiple	multiple	20-point scale	*29*
SHZ	multiple	20-point scale	*34*
multiple	terroir or geography	multiple	*47*
SHZ	multiple	20-point scale	*28*
multiple	multiple extrinsic	James Halliday scores	*48*
SHZ, CAS, MER	wine color and hue	commercial wine quality grade	*12*
multiple	multiple extrinsic (Italy)	multiple	*49*
multiple	climate	multiple	*50*
SHZ	multiple	20-point scale	*24*
tannat	astringency by sensory	consumer panel	*51*
multiple	meteorological information (Italy)	wine vintage quality ratings (1−7 scale)	*52*
multiple	climate (Australia)	multiple	*53*

partners". Many attributes have been associated with wine quality, and these can be broadly separated into intrinsic and extrinsic categories (*1*). Extrinsic attributes include labeling, brand, price, and others, whereas intrinsic properties include age, chemical composition, variety, and others. **Table 1** lists some references that have reported parameters related to wine quality.

Commercial wine quality assessment and the allocation of wines to grades that represent the potential value of that wine in the market are usually performed by experienced company winemakers on the basis of sensory characterization. Such sensory assessment is an inherently subjective measure, prone to biases in individual preferences and day-to-day variability (*14*). Therefore, additional measurements have long been sought that can be used to support the decision-making process associated with grape and wine grading assessments.

Grape pricing, and suitability of the grapes for certain wine styles, can be determined in the vineyard, at the weighbridge, or retrospectively based on the grade to which the resulting wine is allocated, thus highlighting the importance of objective, evidence-based specifications (*15*, *16*). Traditional parameters used to characterize both red grapes and wines include pH, acidity, sugar, and color. Positive relationships between red wine quality scores from expert judges and intrinsic, objective, analytical measurements have also been reported for additional parameters, such as measurements of glycosyl glucose conjugates of aroma molecules (*17*, *18*). In red wines, phenol-free glycosyl glucose (*19*) allows the influence of phenolic glycoside quality markers such as anthocyanins to be decoupled from flavor glycosides. Among the compositional attributes needed to chemically characterize wines are multiple phenolic components such as anthocyanins, total phenolics, and tannin, which are related to color and astringency. As such, various wine phenolics parameters have also been investigated in relation to assessments of red wine quality, and whereas some reports exist in peer-reviewed literature (*20*−*24*), many more are in non-peer-reviewed technical communications (*12*, *25*−*32*).

Research into the role of phenolics in grading has focused on color and total phenolics measurements as they are simple to perform, which is a prerequisite for routine analysis in wine industry laboratories. Over the past decade, the Australian wine industry has adopted such research findings, and currently a large portion of Australian red wine production processes include objective grape and wine color measurements. Information on grape and wine color is used to aid the decision-making process regarding grape maturity assessments, streaming of grape intake, grape grower payment systems, monitoring of quality among vineyards, wine blending decisions, internal wine product specification, and internal quality allocation system and/or for internal research purposes (unpublished data from AWRI industry survey).

Color in grapes and wine has been the major focus of the published work investigating red wine quality and phenolic compounds. The phenolics responsible for wine color are often measured using spectrophotometric measurements; in particular, the "Somers" color measures (*23*, *33*) are used in Australia. Color parameters have shown the largest positive correlations with expert wine scores using small- to medium-sized data sets from within a vintage. A study has been reported in which 32 young red wines were analyzed using the suite of Somers color measurements and the results related to wine quality as determined by a panel of expert judges (*23*). A good correlation was observed between wine quality and young wine color density (expressed as $A_{520nm} + A_{420nm}$), where deeper colored red wines were rated as higher quality than those of lighter color (*23*). Subsequent research studies have supported these findings and have demonstrated a positive correlation between grape and wine anthocyanin concentration and wine quality (*12*, *20*, *26*). Furthermore, studies have shown that the correlation between wine color density and overall wine quality was also evident even when the visual color of the wine was masked (*26*).

The total phenolics parameter has also been shown to positively relate to wine quality (*21*, *27*, *28*, *34*), but no studies investigate this relationship across a broad range of quality levels. There are, however, a few reports of wine tannin concentration in relation to red wine expert scores (*21*, *28*), but again, no studies that investigate across a broad range of quality levels.

It has been speculated that tannin concentration could be used to help establish grape and wine specifications and that red wine tannin concentration may be correlated to red wine quality. It is well recognized that red wine tannins play a critical role in stabilizing wine color and contributing to mouthfeel properties (*11*, *35*). Although established procedures are widely used to measure pH, acidity, sugar, color, and total phenolic content of grapes and wine, measuring tannins in the wine industry has been technically challenging (*36*). Recent research into optimizing

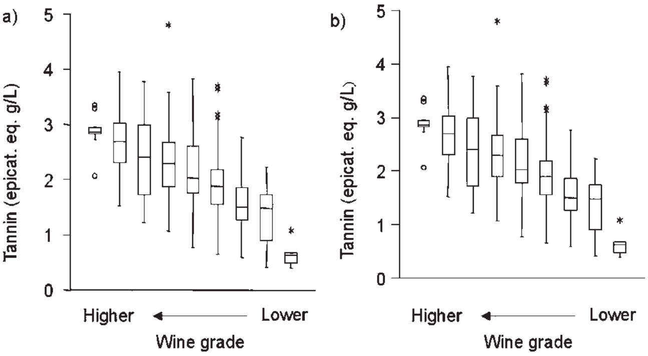

Figure 1. Box plots showing the relationship between tannin concentration and red wine allocation grade as determined by a major Australian wine company (company 1) over the 2005, 2006, and 2007 vintages: (**a**) Shiraz (n = 643, F ratio = 26.4, probability < 0.001); (**b**) Cabernet Sauvignon (n = 380, F ratio = 9.4, probability < 0.001).

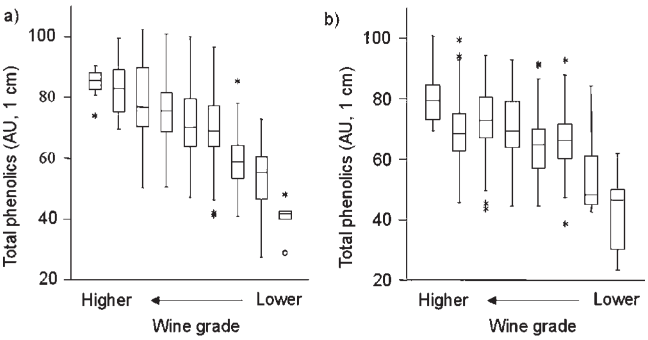

Figure 2. Box plots showing the relationship between total phenolics and red wine allocation grade as determined by a major Australian wine company (company 1) over the 2005, 2006, and 2007 vintages: (**a**) Shiraz (n = 643, F ratio = 35.6, probability < 0.001); (**b**) Cabernet Sauvignon (n = 380, F ratio = 13.9, probability < 0.001).

precipitation-based methods for measuring tannins, using proteins such as bovine serum albumin (*37*) or polysaccharides such as methyl cellulose (*38*−*40*), has reduced the technical requirements for implementation in winery laboratories. In the research reported here, total wine tannins were quantified in Australian Cabernet Sauvignon and Shiraz wines that had been allocated by three Australian companies to a wide range of grades during three vintages. The hypothesis that higher total phenolic and tannin concentrations in red wines is positively related to higher value allocation grades as determined by commercial winemakers is tested.

METHODS AND MATERIALS

Wine Samples and Allocation Grading Assessment. For each company the allocation grade was determined at the "post vintage allocation" classifications, and these were performed annually after vintage, to allocate all wines made during the vintage to a specific quality grading and then to a wine product. Sensory assessments of the wines were performed in-house by groups of senior winemakers; each wine was rated according to specifications particular to the company and then assigned a specific alphabetical or numerical allocation grade. This allocation grading is used by wineries to assign wines to commercial products with particular styles and price ranges and, in terms of "fitness for purpose", is indicative of the quality or price range of the wine. In general, red wine allocation grading was performed over 1 week with up to 24 wines presented in any one bracket and up to 6 brackets presented per day with a break between brackets. Tasters were informed only of the region and the variety, and allocation grade was generally determined by consensus vote. After collection, wines were stored at room temperature until analysis.

Table 2. Basic Statistics (Sample Number, Mean, Standard Deviation) and Results from One-Way Analysis of Variance (ANOVA) between Wine Quality Allocation Grade and Tannin Concentration and Total Phenolics, Respectively, for Shiraz (n = 625) Wines from the 2007 Vintage, Using Data from Three Australian Wine Companies

		tannin (g/L)			total phenolics (au, 1 cm)		
level	n	mean	SD	ANOVA	mean	SD	ANOVA
A	76	2.88	0.58	F ratio	83.2	11.6	F ratio
B	244	2.65	0.65	52.1	78.4	11.6	76.9
C	253	2.22	0.53		70.4	9.6	
D	75	1.85	0.42	probability	60.0	6.8	probability
E	4	1.30	0.61	<0.001	46.4	5.2	<0.001

Table 3. Basic Statistics (Sample Number, Mean, and Standard Deviation) and the Results from One-Way Analysis of Variance (ANOVA) between Wine Quality Allocation Grade and Tannin Concentration and Total Phenolics, Respectively, for Cabernet Sauvignon (n = 384) Wines from the 2007 Vintage, Using Data from Three Australian Wine Companies

		tannin (g/L)			total phenolics (au, 1 cm)		
level	n	mean	SD	ANOVA	mean	SD	ANOVA
A	23	2.71	0.64	F ratio	73.6	10.0	F ratio
B	107	2.79	0.76	16.8	75.2	11.6	33.6
C	108	2.35	0.64		66.8	10.0	
D	129	2.20	0.65	probability	62.0	10.0	probability
E	17	1.77	0.60	<0.001	53.6	8.0	<0.001

Comparison among Three Vintages for One Company (Figures 1 and 2). In the 2005, 2006, and 2007 vintages, 380 Cabernet Sauvignon wines and 643 Shiraz wines were collected from one winery, following post vintage allocation tasting. Wines were selected from 13 winemaking regions within Australia (according to the "Australian geographical indications" (Australian Wine and Brandy Corp.)) and covered the full range of 9 grades in the company. Sample-related information including variety, region, and allocation grade were provided by the wine company.

Comparison within 2007 Vintage among All Three Companies (Tables 2 and 3). The allocation grading systems used by each of the three commercial companies surveyed in 2007 differed slightly. Therefore, to allow for the data from all three companies to be compared (2007 vintage only), the quality grades from each company were consolidated into 5 broad categories (A−E) by combining similar grades (see **Tables 2** and **3**). Two companies had 15 allocation grades, and so the 3 allocation grades within each of the companies' 5 broad categories (A−E) were consolidated. One company had a 9 grade system, and to consolidate into the 5 broad categories, pairs of allocation grades were combined from the highest (i.e., the two highest quality grades became A, the next two became B, etc.) grade to the lowest, with the final, lowest allocation assigned to category E.

Vertical Series. A vertical vintage series of Shiraz and Cabernet Sauvignon wines from the museum cellar of a small producer (Taltarni wines) were analyzed for tannin and total phenolics concentration. The wines were all commercial bottled products, spanning vintages from 1977 to 2006. For the Cabernet Sauvignon wines, some vintages also included "reserve" wines, considered to be of higher quality than their "nonreserve" product.

Analytical Methods. *Methyl Cellulose Precipitable* (*MCP*) *Tannin Assay*. Methyl cellulose solution (0.04% w/v) (1500 cP viscosity at 2%, Sigma-Aldrich, Castle Hill, NSW, Australia) was prepared in accordance with the manufacturer's instructions.

The MCP tannin assay was performed on wines using the high-throughput format as described in Mercurio et al. (*38*). For all samples, 300 μL of supernatant from the treatment and control samples was transferred into a 370 μL Greiner UV star 96-well plate and read at 280 nm. A dual-beam monochromatic SpectraMax M2 UV−visible microplate reader (Molecular Devices, Australia) was used for tannin analysis. The SpectraMax M2 has a built-in path correction function that normalizes the path length of each well to 10 mm. This function allows direct comparison with a reading taken on a conventional spectrophotometer with a 10 mm path length and corrects for any variation in sample volume. For all absorbance readings, water was used as a blank. Aqueous (−)-epicatechin (Sigma-Aldrich) solutions (10, 25, 50, 75, 100, 150, 200, 250 mg L^{-1} epicatechin) were used to establish a calibration chart for reporting tannin absorbances. All A_{280} (tannin) values are reported in milligrams per liter epicatechin equivalents of the original sample (corrected for dilution).

Total Phenolics. The 280 nm reading of the control sample prepared as part of the MCP tannin assay was used to determine the total phenolic of the wine samples. As detailed previously (*38*) the MCP tannin assay requires the preparation of a control sample in which the wine sample is diluted 1 in 40 with a buffer solution containing ammonium sulfate and water. Validation studies have shown the ammonium sulfate solution to have minimal effect on the absorbance at 280 nm (*40*); therefore, the absorbance reading of this solution at 280 nm is reported in au (1 cm) and represents a measure of the total phenolics in the wine sample (corrected for dilution).

Statistical Analysis. One-way analysis of variance (ANOVA, $p < 0.05$) was conducted on the data to investigate the differences between the mean concentrations of tannin and total phenolics due to different quality grades. Additionally, the correlation coefficient (r) was reported, assuming equidistant distribution of the allocation grades.

For box plots, the box represents the central 50% of the distribution, with the horizontal line showing the median. The whiskers represent 1.5 times the interquartile range above and below the central 50% data points. The symbols represent outlying data points. Statistical analyses and figures were prepared using JMP version 5.0.1a (SAS Institute Inc., Cary, NC) and Systat version 10.0 (SPSS Inc., Chicago, IL).

RESULTS AND DISCUSSION

Relationship of Red Wine Allocation Grading with Tannin and Total Phenolic Concentrations within One Company over Multiple Vintages. **Figure 1** illustrates box plots that represent wine grade and tannin concentration for Shiraz (**Figure 1a**) and Cabernet Sauvignon (**Figure 1b**) wines from a single Australian company over the 2005, 2006, and 2007 vintages and included wines from 13 Australian regions across 9 grades. A positive correlation between grade and tannin concentration was observed for both Shiraz ($r = 0.5$, $n = 643$) and Cabernet Sauvignon ($r = 0.39$, $n = 380$) wines. However, the differences between grades were more significant for Shiraz wines (F ratio $= 26.4$, $p < 0.001$) than for Cabernet Sauvignon wines (F ratio $= 9.4$, $p < 0.001$).

Figure 2 illustrates box plots that represent wine grade and total phenolic concentration for the same Shiraz (**Figure 2a**) and Cabernet Sauvignon (**Figure 2b**) wines. A positive correlation between grade and total phenolic concentration was observed for Shiraz ($r = 0.56$) and Cabernet Sauvignon ($r = 0.45$). Similarly to tannin concentration, differences between grades were more significant for Shiraz wines (F ratio $= 35.6$, $p < 0.001$) than for Cabernet Sauvignon wines (F ratio $= 13.9$, $p < 0.001$).

The possibility that grades 1 and 9 were nonlinear relative to grades 2−8 was also considered, but in all cases removal of grades 1 and 9 resulted in a decreased correlation coefficient (data not shown). **Figures 1** and **2** represent a diverse data set and demonstrate that, overall, the correlation between Cabernet Sauvignon and Shiraz wine grade and tannin and total phenolics concentration, respectively, is positive and consistent despite varietal, vintage, and regional variations for these companies. Red wine grade and these two phenolic parameters also correlate well within each vintage and region individually (data not shown). As explained, the post vintage allocation grading system and associated criteria are company specific; therefore, to investigate if this positive correlation held for more than one company, the study was expanded to three companies in 2007.

Relationship of Red Wine Grade with Tannin and Total Phenolic Concentrations in Three Companies in Vintage 2007. Following the 2007 vintage, 625 Shiraz wines and 384 Cabernet Sauvignon wines from multiple regions within Australia, covering a range of styles and price from three wine companies, were analyzed for tannin and total phenolics concentration. Basic statistics and results from one-way ANOVA between wine allocation grade and tannin and total phenolics concentration, respectively, are shown in **Table 2** for Shiraz wines and in **Table 3** for Cabernet Sauvignon wines, using the combined data from the three companies. Again, it was observed that the correlation between quality grading and tannin concentration was positive for Shiraz ($r = 0.46$) and Cabernet Sauvignon ($r = 0.39$) and that the differences between grades are more significant for Shiraz wines (F ratio $= 52.1$, $p < 0.001$) than for Cabernet Sauvignon wines (F ratio $= 16.8$, $p < 0.001$). Similarly, the correlation between quality grading and total phenolics concentration was positive, but higher than with tannin, for Shiraz ($r = 0.53$) and Cabernet Sauvignon ($r = 0.51$), and again the differences between grades are more significant for Shiraz wines (F ratio $= 76.9$, $p < 0.001$) than for Cabernet Sauvignon wines (F ratio $= 33.6$, $p < 0.001$). The larger significance of the differences between grades of these two phenolic parameters with Shiraz as opposed to Cabernet Sauvignon was observed consistently throughout the study.

We have chosen to represent the data in **Tables 2** and **3** using the mean tannin concentration (with SD) for each wine quality grade. Although this gives a good indication of the trend between wine quality and these phenolic parameters, it should be noted that overlap of concentrations between quality grades was observed in most cases. Thus, we are not suggesting that a wine of a particular tannin or total phenolics concentration will necessarily be of a particular quality grade; however, the results do clearly show that on average as these red wine grades increased in quality the concentration of both phenolic parameters in these wines increased and also that statistically significant differences existed between the grades.

Table 4. Statistics for Linear Regression of Tannin and Total Phenolics

sample set	r^{2a}	n^b
allocation samples: all	0.73	1586
allocation samples: Shiraz	0.75	613
allocation samples: Cabernet Sauvignon	0.76	973
vertical vintage series: all	0.86	63
vertical vintage series: Shiraz	0.86	30
vertical vintage series: Cabernet Sauvignon	0.85	33

[a] Coefficient of determination. [b] Sample number.

Relationship between Tannin and Total Phenolics Concentrations in Red Wines. The F ratios from the data in **Figures 1** and **2** and in **Tables 2** and **3** indicate that, independent of variety, vintage, or company, the significance of the differences between grades was slightly larger for total phenolics concentration than for tannin concentration. Tannin is one component of the total phenolics measurement, but the latter also includes structurally diverse low molecular weight phenolics such as free anthocyanins, flavonols, phenolic acids, and other UV-absorbing material. To increase our understanding of the relationship between tannin and total phenolics concentrations in red wines, **Table 4** shows the coefficients of determination from linear regression of these two parameters using a number of red wine data sets. The tannin and total phenolics data from the allocation grading wines (all years and companies) showed moderate positive correlations to each other for the data set with both varieties combined ($r^2 = 0.73$) and for Shiraz ($r^2 = 0.75$) and Cabernet Sauvignon ($r^2 = 0.76$) separately. Note that these samples were all current vintage samples at the time of analysis and so were all < 1 year old. The second set of samples was more diverse in terms of age and

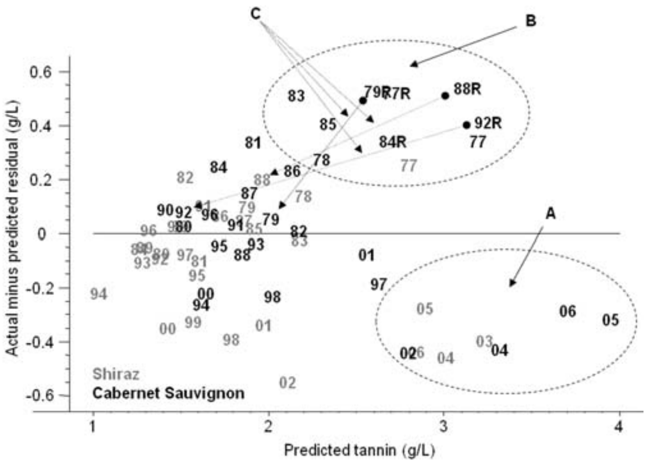

Figure 3. Residuals of the actual tannin value minus the tannin value that is predicted by using total phenolics values (sourced from the linear regression of total phenolics and tannin (r^2 = 0.86)), plotted against the predicted tannin value. Samples are marked with the last two numbers of the vintage, and reserve wines are marked "R". Cabernet Sauvignon samples are marked in black and Shiraz in gray. Cluster A marks high-color, high-tannin young wines that are overpredicted for tannin. Cluster B marks old, high-tannin wines that are underpredicted. Arrows C highlight "standard" and "reserve" pairs of the same vintage.

comprised a vertical series of Shiraz and Cabernet Sauvignon wines from 1977 to 2006. These showed stronger positive correlations between tannin and total phenolics for the data set with both varieties combined (r^2 = 0.86) and for Shiraz (r^2 = 0.86) and Cabernet Sauvignon (r^2 = 0.85) separately.

Although these data sets demonstrate that tannin and total phenolics concentration are positively correlated with each other, **Figure 3** highlights that these parameters should not be used interchangeably. **Figure 3** shows a residuals plot from prediction of the tannin value using the total phenolics value for the vertical series data set incorporating both varieties (r^2 = 0.86). A residual plot shows whether the regression model is a good fit to the data. If the residuals are curved or have a slope, then the regression model is not accounting for all of the data variability, and if the plot is not the same width throughout the range, the data may not have equal variance. Strong regression models give uncorrelated residuals with no recognizable pattern. **Figure 3** demonstrates clustering and increasing nonuniformity along the horizontal axis, which indicates that the higher the tannin concentration is, the more poorly the total phenolics value predicts the tannin value. For example, younger wines that are high in color and tannin (cluster A) are overpredicted, whereas older, high-tannin wines are underpredicted (cluster B). Interestingly, this data set provides further evidence that higher quality wines tend to be higher in tannin, as arrows C connect pairs of "standard" (79, 88, 92) and "reserve" (77R, 88R, 92R) Cabernet Sauvignon wines of the same vintage. The three reserve wines have significantly higher tannin concentrations than the standard wines (p < 0.001; mean tannin for reserve wines was 3.22 g/L; mean tannin for standard wines was 2.08 g/L).

Tannin and Total Phenolics in Relation to Grading. On the basis of the research presented here, we propose that both tannin and total phenolics concentrations should be considered when developing multiparameter chemical metrics for assigning red wine to quality grades. On the one hand, measuring tannin can provide more practical sensory information than total phenolics because it can be directly related to functional characteristics such as astringency and color stability. On the other hand, total phenolics provide a good overall measure of phenolic extraction, including colored and noncolored phenolics, all of which can be significantly influenced by different growing and winemaking processes. Indeed, when coupled with the existing body of evidence demonstrating the role of color in red wine quality, it is likely that all three phenolic parameters (tannin, total phenolics, color) in combination may increase the success of multivariate models aimed to assist sensory-based allocation of red wines to relevant grades. Spectroscopy can be used to capture much of the intrinsic, multivariate chemical information in a food or beverage (*41*) and, for example, it has been demonstrated that visible−near-infrared spectroscopy can be used to predict red wine quality scores (*42*). Ultimately, chemical composition models to assist the commercial grading of wine are likely to be based on an index of numerous parameters, weighted variably depending on the product or market, as has been the situation in other areas of food science (*3*−*7*). The work described here indicates that both wine tannin and total phenolics concentration should be two of the parameters considered in such a wine grading index.

Conclusions. On the basis of data collected from one major Australian wine company over the 2005−2007 vintages and another two major companies in 2007 (total wines = 1643), statistical analysis revealed a trend toward higher wine grade allocation when wines had higher concentrations of total phenolics and tannin, respectively. This research demonstrates that, at least for the major Australian Cabernet Sauvignon and Shiraz styles, red wines allocated to grades with higher market value have higher total phenolics and higher tannin concentrations. Hence, we suggest there is a case to consider these two compositional parameters in the development of multiparameter models to support commercial wine grading processes. Both tannin and total phenolics would ideally be included because although a general positive relationship exists between the two parameters, this relationship does not hold for all wine styles. More broadly, analyzing for color, tannin, and total phenolics, either routinely or during research trials, will provide a greater understanding of how phenolic concentrations are affected by, or relate to, a range of production variables, including changing seasonal conditions, new and innovative vineyard management practices, terroir, wine-processing techniques, and consumer preferences.

ABBREVIATIONS USED

MCP, methyl cellulose precipitable; au, absorbance units; ANOVA, analysis of variance; SD, standard deviation.

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