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What do wine consumers like? Contextual effects on perceptions and preference, and the role of wine attributes driving emotions and willingness to pay.



FINAL REPORT to

WINE AUSTRALIA

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1. Abstract

To entice consumers to purchase Australian wine, knowledge of how intrinsic wine properties are related to consumers' perception is needed. This project employed wide-ranging methods (chemical, sensory, qualitative and quantitative online/offline consumer research) to investigate:

i) intrinsic drivers of Shiraz wine quality and,

ii) the influence of context effects and,

iii) the effects of specific wine flavours,

on consumers wine-evoked emotions, preferences and purchase decisions. Project outcomes produced deeper insights of consumers' wine behaviour and novel consumer tools to enable the Australian wine industry to tailor desirable wines and shift away from a producer driven toward a consumer driven operation.

2. Executive summary

For the Australian wine sector to be competitive, it requires a perfect fit with the market and produce wines consumers want. When attempting to link intrinsic wine properties to consumer behaviour, one finds parts of the puzzle missing: a lack of understanding of consumers' perceptions of wine quality and the emotions evoked by wine and how these relate to consumer preferences and purchase. Although wine aroma and flavour are essential elements underpinning all wines, consumer perceptions are more likely to be influenced by a product's emotional profile and the context of consumption. This project is unique as it investigates these missing links between intrinsic wine properties and consumers' purchase. The project firstly investigates the intrinsic sensory drivers behind wine consumers' perception of quality and how that relates to experts' perceptions of wine quality for wines at different price points. Secondly it will examine the influence of context on consumer wine quality perception and preference and finally, which emotional responses are elicited by certain wine flavours and how this influences consumers' perception of wine quality and preference. The research uses multiple methods (chemical, sensory, qualitative and quantitative online/offline consumer research) to study context effects while concurrently validating web-based consumer measures. This will deliver insights to develop better wine and pave the way to a radical change in how the Australian wine industry interacts with consumers. Practical implications include:

- New wine market segmentation methods (Wine Neophobia Scale) to measure wine consumer reluctance to try new wines so the Australian wine industry can profile and discover who these consumers are and to better understand their needs in future.
- A specific lexicon (AWEEL) designed to measure Australian wine consumer wine evoked emotions to provide deeper consumer insights over and above wine liking and acceptability data.
- In depth understanding of the wine sensory attributes and chemical compounds that drive consumers' liking, emotions, willingness to pay for commercial Shiraz wines and the relationships between consumers' and experts' quality perception of Shiraz wines so producers can promote these components in their wines.
- Attenuated Total Reflectance Mid-Infrared (ATR-MIR) Spectroscopy has been identified as a promising method to predict phenolic composition of Shiraz wines and Shiraz quality.

- Robust validation of wine consumption context (laboratory, restaurant, home) impacts on consumer liking, emotions and willingness to pay leading to improved consumer testing in future.
- A new rapid methodology to measure what consumers smell, taste and feel in wines permitting producers to communicate to consumers in a language they understand and the basis of a new tool that could be adapted for and utilised by the wine industry to produce sensory profiles and statistical analysis of their wines negating expensive sensory testing.
- Knowledge of how wine description information, such as the wine sensory characteristics of smell, taste and mouthfeel along with wine quality and producer information impacts wine consumer emotions, liking and willingness to pay.
- How key wine flavour compounds are perceived in the Australian, US and UK markets and which are most suited to specific occasions and seasons which could assist tailoring products more precisely for these markets.
- First time wine flavour and mouthfeel evoked consumer emotional responses determined and detailed consumer perception of wine body defined.

These insights together with the developed tools will assist a business practice change, shifting from a producer driven to a more consumer driven Australian wine industry.

The outputs of this project were achieved by additional support from the School of Agriculture, Food and Wine at the University of Adelaide in the form of operating funding for two Masters of Viticulture and Oenology coursework research projects and one Bachelor of Viticulture and Oenology honours student. The post-doctoral research fellow also obtained financial assistance to attend conferences from the Faculty of Sciences at the University of Adelaide and Elsevier. We also gratefully acknowledge the assistance of eight French University student interns, who performed numerous experimental measurements and helped with setting up consumer trials and sensory panels over the life of the project.

3. Background

The Australian wine sector faces a number of challenges including, increasing competition in the global wine market. In response, the sector needs an enhanced understanding of which wine attributes consumers like, and drive their purchases. These consumer insights should feed back into industry product improvement and/or new product development cycles. Currently, Australian wine business to consumer communication is not optimal and the tools used to obtain consumer information are less than reliable, particularly in relation to measures of intrinsic product quality.

Therefore, it is essential for the Australian wine sector to possess the best understanding of what consumers want, and how this knowledge can be rapidly utilized for new/improved products. This requires an approach avidly embraced by other industries; consumer-oriented New Product Development. This concept starts with end-consumers and translates consumer perceived benefits into desirable product attributes, guiding product development. When building the information chain from consumers to tangible products (wines) it is clear that there's a lack of understanding of consumers' perceptions of wine quality and how that relates to consumer preferences and purchase, mainly because of the minimal amount of consumer-focused R&D and the type of consumer measures utilised. Traditional wine sensory-consumer testing has frequently used over-simplified methods which don't take the context or consumer psychographics (attitudes, emotions, behaviours) into account and therefore do not predict real-life consumer behaviour. Current opinion in consumer/sensory science states that one "must-have" is an understanding of the context effects on consumer research results. Carefully managing the trade-offs in our move toward the now more accepted realism versus laboratory controlled research, will make our results more relevant to the real world.

Studies examining interactions between consumption setting, related information and the validity of wine consumer quality preference and purchase data have not been published. Also, flavour and aroma compounds in foods impact consumer emotions and thus perceptions of quality and preference. Analogous studies of the many key volatile (aroma) and non-volatile (e.g. tannin) compounds in wine are lacking. Consequently, the utility of purposefully altering wine composition to influence consumer perception and emotional status not only necessitates research, but the findings may also provide the knowledge to more effectively produce wine styles of a specified flavour profile targeted for specific market segments and occasions.

Furthermore, the sensory/compositional properties of wines at various price points and how they influence consumer perception of wine quality relative to experts, emotions and preference in major and emerging wine markets are not known. This makes producing wines suited to particular markets problematic. Furthermore, the plethora of small-medium sized wine business does not have the means to conduct such high-level consumer research at the pre-competitive stage nor the ability to interface with consumers to design new or alternative products.

These factors suggest that the time to seize a more consumer-centric approach is now, to provide:

- improved methods available to the wine industry to capture high quality consumer information from more people more easily and cost efficiently locally and internationally,
- an understanding of wine composition as it relates to consumer emotions, perception of quality and purchase decisions in different usage situations and,
- a radical improvement in our ability to tap into consumers' needs and wants so as to more efficiently respond to changes in local and international markets. This will allow for a more rapid production of wine styles that fully meet consumer specifications and thereby translate to increased profitability.

4. Project aims and performance targets

This project seeks to generate improved knowledge and understanding of wine consumers leading to more rapid and faithful delivery of desirable Australian wines. A desirable wine refers to one possessing the correct sensory attributes, for a particular situation or mood, as required by consumers in Australia's major and emerging markets.

i. The nature of the intrinsic sensory wine drivers behind wine consumers' perception of wine quality within different market segments versus experts' perception of wine quality for wines at different price points.

ii. The influence of a variety of consumer wine evaluation context effects (mood, occasion, setting, etc) on consumer wine quality perception and wine preference ratings to define conditions which will ensure the most robust measures of consumer wine preference.

iii. To assess which emotional responses are elicited by certain wine flavours and how this influences wine consumers' perception of wine quality, preference and purchase decisions. This may offer the Australian wine industry the potential to develop wines best suited to the consumers' consumption occasions and experiences providing an advantage over competitors.

The following tables list the performance targets and activities as outlined in the project contract.

Year 1

Output	Activities
University of Adelaide Post-doctoral research fellow appointed	Advertise 3 months prior to appointment
Web-based platform builder engaged	Seek provider to build co-creation platform
Industry reference group formed	Canvas industry to join a group to inform the production of the co-creation platform and study advisors
Australian wine consumer data base for platform generated	Purchase and recruitment of eligible Australian wine consumers in local and international markets
Australian wine consumer study on wine aroma and emotion conducted	Literature review, generate consumer survey (after qualitative study on wine aromas and relationships with consumer emotions), recruit consumers to undertake survey

Year 2

Output	Activities
Qualitative knowledge of the relationship between wine aroma and consumer emotion	Monitor consumer responses to wine aroma and emotions study, Close wine aroma and emotions study. Data analysis of wine aroma and emotion survey.
Nature-identical flavour compounds to spike wines for second consumer trial on intrinsic aromas and emotions purchased	Identify candidate aromas to examine in producer-consumer co-created wines based on wine aroma and emotion survey data and from literature search.
Final set of commercial wines from different price points for descriptive analysis, wine chemistry and consumer trials purchased	Scoping suitability of a range of commercial wines, determining wine price points to be examined and determining most appropriate variety with industry consultation
Web-based producer-consumer co-creation platform for a dedicated wine online community launched	Development, building and validation of operability of producer-consumer co-creation platform
Sensory profiles of commercial wine from different price points defined	Recruitment of descriptive analysis (DA) panellists, sensory panel established, trained and DA of commercial price point wines performed.

Flavour chemistry profiles of commercial wines completed	Measure wine flavour compounds using GC-MS. Statistical analysis (PCA, PLSR, MFA) of data sets to identify correlations.

Year 3

Output	**Activities**
Knowledge of environment effects on and intrinsic wine drivers behind wine consumer quality perception, preference and purchase	Utilise the co-creation platform interface and conventional methods to conduct central location (UA sensory lab), controlled situation (e.g. restaurant, BBQ) and home use consumer trials of commercial wines
Understanding of relationships between wine expert quality ratings and consumer quality ratings	Conduct wine expert sensory evaluation of commercial wines and statistical analysis of correlations with consumer data and DA and flavour chemistry measures
Manuscript for peer review journals, industry articles and innovator network report submitted	Writing manuscripts and innovators network report
Final set of aroma spiked wines selected for consumer trial	Bench top testing and consumer focus panels of nature identical aroma spiked wines
Quantitative sensory profiles of aroma spiked wines produced	Recruitment of descriptive analysis (DA) panellists, sensory panel established, trained and DA of aroma spiked wines performed.

Year 4

Output	**Activities**
Flavour chemistry profiles of aroma spiked wines completed	Measure wine flavour compounds in final set of aroma spiked wines using GC-MS. Statistical analysis (PCA, PLRS, MFA) of data sets to identify correlations.
Knowledge of interactions between wine aroma, wine consumer emotions and environment	Survey preparation, conduct consumer trials of aroma spiked wines using best practice methods identified in year 3. Statistical analysis (PCA, PLRS, MFA) of data sets to identify correlations.
Conference presentation at 16th AWTIC	Conference preparation for 16th AWTIC
Manuscript on wine aroma/consumer emotion for peer review journals, industry articles and innovator network report and final GWRDC report submitted	Writing manuscripts and innovators network report and final GWRDC report

The online platform to capture consumer data had been under development for over one year involving significant input on behalf of the University project team. All wire frames (the front and back end of the portal) were generated. However, due to unforeseen, outside forces affecting the platform provider, a fully functional portal for testing and refining before live portal deployment was not completed. The equivalent monies spent for this component of the project was deducted from the overall awarded funds and the project objectives and outputs modified after agreement between the University of Adelaide and AGWA. In the platforms' place, novel and rapid consumer science methodologies were developed to gather wine consumer information robustly and quickly while using consumer language, which could have significant flow on effects for the wine industry. Additionally, a database of over 1000 consenting consumers was created and used to manage and recruit consumers for the tasting trials.

5. Methods

To achieve the project aims, a multidisciplinary research approach was used. This encompassed a mix of quantitative and qualitative online surveys; fundamental sensory science; sensory marketing; consumer research and wine chemical compositional analysis. In a first step, new scales to conduct consumer segmentation (i.e. group consumers with similar behaviours into smaller clusters to gain more detailed consumer insights) and a means to measure wine-evoked emotions relevant for Australian wine consumers, had to be developed. Originally, to recruit consumers and receive consumer feedback, an online platform was to be developed, however due to reasons outlined above in section 4 Project aims and performance targets this step was subsequently excluded. Thus, consumer recruitment was performed using, traditional recruiting methodologies and consumer feedback gathered by existing best practice and more novel approaches generated and subsequently validated in the current project. These methods were applied together with detailed volatile (aroma and flavour compounds) and non-volatile (major wine chemical compounds) chemical analysis, sensory profiling with trained panels and winemaking experts and best practice consumer and sensory methodology, to answer the specific research questions of this project.

5.1. Development of the First Australian Wine Evoked Emotions Lexicon (AWEEL) for consumers

Traditionally, consumer product acceptability is measured using hedonic (liking) scales, but this does not provide deep insight into consumers' feelings about a product (Köster, 2009). To overcome this limitation, recent research suggests that the investigation of product-evoked emotions can provide additional information to liking (Danner, Haindl, Joechl, & Duerrschmid, 2014; Jiang, Niimi, Ristic, & Bastian, 2017; King & Meiselman, 2010; Mojet et al., 2015; Porcherot et al., 2012) and can be a better predictor for food choice than liking alone (Dalenberg et al., 2014).

Although consumer emotions in relation to food and beverages is currently an active area of research, a single paper had been published on wine at the commencement of this project. This reported an emotion lexicon specific for wine consumption generated through the process of word list reduction (Ferrarini et al., 2010). However, when this lexicon was translated into English, a bench top test with a small number of participants in the current project in 2013,

found that some of the emotion terms were ambiguous, or unsuitable for an Australian wine consumer audience. This is now in agreement with previous research that has shown that both culture and language needs to be taken into consideration when designing emotion lexica (van Zyl & Meiselman, 2015, 2016). Therefore, a wine consumer-led adaptation of an existing emotional lexicon for food by Richins (1997) was determined to be a better means to measure wine-evoked emotions of Australian wine consumers.

Using wine consumer focus panels (target consumer focus group tastings to gain consumer attitudes and sensory perceptions about a product), the Consumption Emotions Set (Richins, 1997) was presented to 113 regular wine consumers grouped in 8 focus panels based on gender (male or female only), age (under or over 35 years of age) and a preference for red or white wines. It has been shown that focus groups are an efficient and effective way to generate consumer-led emotion lexica (Chaya et al., 2015; van Zyl & Meiselman, 2015).

The focus panel participants were given four wine samples, either red or white, with modified sensory profiles. To enhance white wine flavour with lemon, passion fruit, peach and vanilla flavours, and red wine with blackberry, mocha, peppermint and aniseed; food grade flavours were added to commercial wines to intentionally evoke different emotional responses and facilitate discussion. The selection of the flavour additions was based on preferences for wine flavours indicated by 1031 wine consumers from our earlier research (Saltman, Johnson, Wilkinson, & Bastian, 2015) and an online questionnaire with another 1000 Australian wine consumers conducted in the current project (Danner, Ristic, Hoek, Johnson and Bastian, unpublished, see section 6.2.1). During focus panels, the participants were asked to: (i) indicate their liking of the wines; (ii) indicate the emotions they perceived while tasting the wines with the different flavour profiles, including any emotions perceived that were absent on the Consumption Emotions Set. Participants reported their initial responses individually in written form, followed by a group discussion. The Richins' (1997) Consumption Emotions set comprised 16 categories each containing 2 or 3 specific emotions; e.g. the category joy covered happy, pleased and joyful. At the conclusion of the group discussions, it was decided by consensus to keep all the emotion categories, but also extend the set by adding two more categories, thought especially relevant for wine consumption; i.e. with the addition of 'adventurous" and "relaxed". Furthermore, the "lonely" category was replaced with "nostalgic".

These results/selections were fed into the second phase in which a further 105 wine consumers were asked to select only one emotion in each of the 16 categories that they considered as the most relevant to wine consumption. Based on selection frequencies the resulting lexicon, consisted of a final set of 19 emotions, including 11 emotions with positive valence (see Table 1). This emotion lexicon was named the Australian Wine Evoked Emotions Lexicon (AWEEL) published in Danner et al. (2016).

Table 1: Australian Wine Evoked Emotions Lexicon (AWEEL) as published in Danner et al. (2016)

Positive (11)	'adventurous', 'calm', 'contented', 'enthusiastic', 'happy', 'nostalgic', 'optimistic', 'passionate', 'relaxed', 'surprised' and 'warm-hearted'
Negative (8)	'embarrassed', 'envious', 'irritated', 'lonely', 'panicky', 'sad', 'tense' and 'unfulfilled'

5.2. Development of the Wine Neophobia Scale: a new wine consumer segmentation base

Target consumers are not a homogenous group, but rather are made up of smaller clusters of people that display distinct behaviours, needs and preferences peculiar to that cluster. The method of identification of these clusters is known as consumer segmentation (Kotler et al., 2010). Segmentation may be conducted by standard demographic measures such as e.g. gender, age, income and wine consumption frequency, but also by increasingly sophisticated bases using psychographics such as attitudes, interests and opinions (Plummer, 1974); wine liking scores (Crump, Johnson, Wilkinson, & Bastian, 2015); wine knowledge (Johnson & Bastian, 2007) or fine wine behaviour (Johnson & Bastian, 2015).

The range of wine styles and wines available on the market is globally increasing, creating even more choice for wine consumers and competition for wine producers, e.g. Dan Murphy's currently lists 6088 red wines and 2796 white wines on their homepage (Dan Murphy's, as of the 30th of May 2017). Hence, the promotion of new wines can be very difficult for wine producers and marketers. Wine consumers' behaviour and willingness to take a risk and try a new wine are influenced by multiple factors including consumers' wine expertise, wine knowledge, wine involvement, sensory preferences and personality traits (Lockshin & Corsi, 2012). To assess wine consumers' reluctance or readiness to purchase and try new and/or

unfamiliar wines or wine styles, the Wine Neophobia Scale (WNS) was developed. Neophobia is defined as an extreme or irrational fear or dislike of anything new or unfamiliar. Therefore the aim was to provide marketers, researchers and wine producers with a new, validated segmentation tool to guide their product positioning and marketing strategies (i.e. based on identified consumers' needs that then determine to whom the product is best suited and how to optimally attract consumers to a product or how to optimally communicate the product to consumers).

To develop the scale, the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992) was used as a starting point and modified by substituting the word "food" with "wine" and removing questions not linked with wine consumption. Based on the responses of 207 university staff and students and following exploratory factor analysis and confirmatory factor analysis, the scale was further modified. Next the test/retest reliability and validity of the newly developed scale was conducted on a cohort of 471 regular wine consumers. This resulted in the published tested and validated final eight item Wine Neophobia Scale (WNS) as shown in Table 2 (Ristic, Johnson, Meiselman, Hoek, & Bastian, 2016).

Table 2: Wine Neophobia Scale as published by Ristic et al. (2016)

1	I like going to places serving wines from different countries
2	I will drink almost any wine (R)
3	I am afraid to drink wine I have never had before
4	At social gatherings, I will try a new wine (R)
5	I like wines from different countries (R)
6	If I do not know what wine it is, I won't try it
7	I do not trust new wines
8	I am constantly trying new and different wines (R)

(R) indicates negatively worded items for which scores need to be reversed for collation of the WNS score. Items are scored on a 9-point scale, anchored from strongly disagree to strongly agree.

5.3. Shiraz wine expert tasting to select wines for future consumer, expert and wine quality realtionships and context studies

One hundred Australian Shiraz wines were sourced from 24 wine regions across Australia: i.e. Barossa Valley (24), McLaren Vale (16), Margaret River (8), Yarra Valley (7), Adelaide Hills (6), Coonawarra (5), Heathcote (5), Riverina (4), Clare Valley (4), Great Southern (3), Hunter Valley (3), Grampians (2), Geographe (2), Canberra (1), Central Ranges (1), Orange (1), Beechworth (1), Murray Darling (1), Bendigo (1), Great Western (1), Pyrenees (1), Rutherglen (1), King Valley (1) and Swan Valley (1). The vintages ranged from 2009 to 2013 and the retail prices from AUD 3 to AUD 185. The selection of the wines was based on The Nielsen Company Australia market report of the top most sold Shiraz wines in different price categories, wine show medals, Langton's wine classification, popularity by best sellers and known brands and wine expert recommendations. Wines were stored at 14 °C for approximately one month prior to analysis.

An expert panel of 8 judges which qualified as wine experts according to Parr (2002) was convened. Judges were asked to rate all 100 wines on a scale from 1 to 20, following the conditions of the Australian 20-point wine show scoring system, and place them consensually into one of four quality categories of gold (G), silver (S), or bronze (B) medal, or no medal (NM) but of sound quality. Prior to tasting the criteria corresponding to each quality category were agreed upon by all the experts. Experts were asked to declass any wine with an obvious wine fault (e.g. reduction, oxidation, smoke or cork taint). All wines (30 mL) were presented in a bracket of 25 in randomized order across experts. Wines were served at room temperature (~20 °C) in clear three-digit coded INAO (ISO standard) glasses covered with a glass lid. Water and plain crackers were provided for palate cleansing and there was an hour break between each bracket. The experts provided their wine scores in each bracket and the panel leader placed each wine in an appropriate quality category. If experts disagreed the wine was blind scored again in an additional bracket.

Out of these one hundred wines, ten of each quality level, representing different wine regions all over Australia, were selected for chemical and descriptive sensory analyses.

All chemical analyses were performed at the University of Adelaide in duplicate for three bottles of each wine and included:

- Standard chemical composition (pH, TA, sugars, alcohol, VA)
- Phenolic composition (Somers measurements)

- Flavour profile by GC-MS (oak volatile, scan of 26 volatiles, low molecular weight sulfur containing compounds)
- Attenuated total reflectance-mid-infrared (MIR) Spectroscopy

Based on threshold values of the analysed volatile flavour compounds, Odour Activity Values (OAV) were calculated and only compounds having an OAV above 1 were included in subsequent data analyses.

A trained descriptive analysis panel (n=12) profiled the sensory characteristics of the 40 wines in triplicate, rating 17 aroma, 15 flavour and 7 selected mouth-feel attributes.
Out of the 40 wines, three of each quality level were selected, based on experts' opinions and availability for consumer evaluation.

Three independent consumer trials (trial 1 n=114, trial 2 n =113, and trial 3 n=120) examined 3 different sample sets of 4 Australian commercial Shiraz wines. Each sample set was comprised of a high (gold), medium-high (silver), medium-low (bronze) and low (no-medal) quality wine as designated by an expert panel. In total 347 consumers evaluated twelve wines randomised and coded, stating their liking, subjective quality rating and product-evoked emotions

5.4. Wine sensory profiling with descriptive analysis

All wines used in the consumer and expert studies underwent detailed sensory profiling using descriptive analysis (DA) with trained panellists to objectively describe the sensory (aroma, taste, flavour, mouthfeel and after taste) characteristics of the wines. The DAs were conducted within 3 months of all the consumer and expert studies and chemical analyses to prevent changes in the sensory profiles of the wines affecting data interpretation and results caused by wine aging.

All DAs followed the procedure outlined by Lawless and Heymann (2010) and consisted of a series of training sessions followed by formal evaluation sessions. The panellists were screened using ISO standards regarding aroma and flavour threshold sensitivity; their capacities to describe their sensory perceptions and their ability to work in a team. Panellists tasted wines under blind conditions .i.e. at no time were they provided information about the wines other than them being commercial red or white wines. During the training, assessors developed a

wine vocabulary and were trained in sensory attribute recognition using reference standards and familiarised with the individual sensory booths where formal evaluation would take place. The following sessions focused on panellist sample discriminability by sensory attribute intensity (strength) rating, repeatability and consensus among assessors. After successful completion of a pre-test proving that the panel agreed on the sensory characteristics of a subset of the samples and could discriminate and profile them in a repeatable way, the formal assessment sessions were conducted.

During the formal evaluations, 10-12 panellists evaluated the samples in duplicate in isolated booths of the sensory laboratory at the University of Adelaide. The wines were presented to the panellists as 30 mL samples in coded ISO standard wine glasses, one at a time, and in randomised order for each panellist. The panellists rated the intensity of the sensory attributes agreed upon and defined during training sessions using a horizontal, 15cm line scale on a computer screen. Specialised sensory software was used to collate the data from all the panellists. Breaks of a minimum of 60s were enforced between samples and panellists instructed to neutralise their pallet using unsalted crackers and water.

After confirming that the panel performed according to the quality guidelines regarding discrimination ability, repeatability and panel agreement data was analysed using a standard two-way ANOVA with panellist as random and samples as fixed factor.

5.5. Chemical analysis of wines

All wines used in this project underwent detailed chemical analysis including basic and volatile chemistry.

For the Shiraz red wines, basic chemical composition (pH, titratable acidity (TA), volatile acidity (VA), alcohol content (as % alcohol by volume, abv), fructose and glucose) were determined by the Australian Wine Research Institute's (AWRI) Commercial Services Laboratory (Adelaide, Australia) using a FOSS FTIR WineScan. For all other wines and measures, basic chemical measurements including pH, titratable acidity (TA), residual sugar, alcohol and total phenolics, were performed according to published methods (Iland, Bruer, Edwards, Weeks, & Wilkes, 2004). Wine pH and TA (as tartaric acid equivalents to a pH 8.2 endpoint) were determined using the Crison CE95 Compact Titrator fitted out with a Crison

Sampler 15 autosampler (Crison Instruments, SA, Alella, Spain). Residual sugar was measured enzymatically as total glucose and fructose (Boehringer-Mannheim/R-BioPharm, Darmstadt, Germany) with a liquid handling robot (Corbett 3800) and spectrophotometric plate reader (Tecan M200 Infinite). Alcohol content (as % abv) was measured with an alcolyzer (Anton Paar GmbH, Graz, Austria). Total phenolics was measured as the absorbance of wine at 280 nm, using either a GBC Cintra 40 or GBC Cintra 4040 UV-Visible spectrophotometer (GBC Scientific Equipment, Melbourne, Australia).

Analysis of Shiraz wines by attenuated total reflectance-mid-infrared (MIR) spectroscopy was performed in duplicate with the assistance of Dr Daniel Cozzolino. Samples were taken from two different bottles and scanned using a platinum diamond ATR single reflection sampling module cell attached to a Bruker Alpha instrument (Bruker Optics GmbH, Ettlingen, Germany). The MIR spectra of samples were collated on OPUS software (version 7, Bruker Optics) by taking the average of 32 scans at a resolution of 8 cm−o, acquired between 4000 and 400 cm−o, and with a scanner velocity of 7.5 kHz on a background of 32 scans. After every four samples, air was used to record background reference spectra.

Oak flavour compound analysis (*cis*- and *trans*- oak lactone, guaiacol and 4-methyl guaiacol, 4 – ethylphenol, vanillin, furfural, 5-methyl furfural and eugenol) were quantified according to Stable Isotope Dilution Assay (SIDA) methods as reported previously (Pollnitz, Pardon, & Sefton, 2000; Pollnitz, Pardon, Sykes, & Sefton, 2004) using an Agilent 6890 gas chromatograph coupled to a 5973 mass selective detector (Agilent, Palo Alto, CA, USA) and electron impact ionization. The low molecular weight sulfur compounds (hydrogen sulphide, methanethiol, ethanethiol, dimethyl sulphide, carbon disulphide, diethyl disulphide, methyl thioacetate, dimethyl disulfide, ethyl thioacetate, diethyl disulphide) were also analysed using gas chromatography with sulfur chemiluminescence detection (GC-SCD) (Siebert, Solomon, Pollnitz, & Jeffery, 2010). These chemical analyses were conducted by the AWRI's Commercial Services Laboratory (Adelaide, Australia).

Flavour profiles were analysed by headspace solid-phase micro-extraction-gas chromatography-mass spectrometry (HS-SPME-GC-MS). All internal standard chemicals had a purity of ≥ 97% and were obtained from Sigma-Aldrich (Castle Hill, NSW, Australia) or supplied by Alfa Aesar (Ward Hill, MA, USA) and water was obtained from a Milli-Q purification system (Millipore, North Ryde, NSW, Australia). Deuterium-labelled internal

standards were supplied by CDN isotopes (Pointe-Claire, QC, CA). SPME fibres 1cm, divinylbenzene/carboxen/polydimethylsiloxane, 50/30 µm 23 Ga metal alloy were purchased from Supelco (Bellefonte, PA, USA).

The volatile composition of all samples were analysed in duplicate based on the method and conditions described by Siebert et al (2005). Samples were spiked with 25 µL of a mixture of internal standards, prepared volumetrically in absolute ethanol prior to HS-SPME-GC-MS.

HS-SPME-GC-MS was performed using a Gerstel autosampler with agitator (Lasersan Australasia Pty Ltd., Robina, QLD, Australia) coupled to an Agilent 7890A gas chromatograph with an Agilent 5975C mass selective detector (Agilent, Forest Hill, VIC, Australia). A deactivated SPME inlet liner (0.75 mm i.d., Supelco) was used and the GC column was a DB-WAX (60 m, 0.25 mm, 0.25 µm, Agilent J&W, Folsom, CA, USA). The transfer line was set at 230° C and positive ion electron impact spectra at 70 eV were recorded in the scan mode in the range of m/z 35–350. Instrument control and data analysis were performed with Agilent ChemStation software (E.02.02.1431). Identification of compounds was performed using chemical standards. When these were unavailable identification was carried out through mass spectral library matches (NBS 75K), and comparison of gas chromatographic retention and mass spectrometric data reported in the literature.

5.6. Consumer testing

Participants for the consumer tastings were recruited using an existing consumer database belonging to Dr Bastian in the department of wine science at the University of Adelaide, which was extended throughout the project using newspaper adverts and social media (i.e. Facebook). The common approach for all studies was to screen the database for suitability regarding the specific inclusion criteria such as basic demographic data and wine consumption behaviour. Suitable consumers were invited to complete a more specific online survey to further screen potential participants and also collect study specific information beforehand, to minimise the time expenditure for the actual tasting sessions.

During all tasting sessions, consumers were provided with water and crackers to cleanse their palate to prevent carry-over effects and the number of wine samples assessed minimised to avoid palate fatigue and limit the volume consumed.

5.6.1. Shiraz wine quality and context trials

The aims of this study were to examine:

i) the relationship between consumers' product liking, purchase intent and wine-evoked emotions when tasting Shiraz wines of different quality and,

ii) the influence of consumption context (in the sensory laboratory, restaurant, at home) on consumers' hedonic evaluation and emotional responses.

To address the study aims, 3 independent consumer tasting trials were conducted with a total of 347 regular wine consumers and 12 Shiraz wines. In each trial, every consumer:

- evaluated 4 different Australian Shiraz wines, representing the 4 quality levels of the Australian wine show system (ranging from no medal to bronze, silver and gold) as determined by the Shiraz wine expert tasting (section 5.3),
- under each of three different consumption contexts; in the sensory laboratory, in a restaurant and at home, with at least one week between each context,
- stating their liking (on a 9-point hedonic scale), willingness to pay, wine quality and wine evoked emotions (using the developed AWEEL, section 5.1)

The context and presentation order of the 4 wines were randomised across participants. The wines were presented in coded ISO glasses in the laboratory and the restaurant. The wines for the home-use-test were either posted or given to the participants after the previous session. The bottles for home use had an A6 size white label placed around the middle to cover the original label and were spray painted black. Any embossed metal screw caps were masked with back resin. At the restaurant and at home the participants could freely choose what food to consume while tasting the wines and how much of the sample they wanted to consume.

Data were analysed using a mixed model ANOVA approach to investigate wine quality and context effects on liking and emotional responses. To investigate the influence of wine quality on consumers' willingness to pay, a Chi-Square test with consecutive z- tests were performed. The relationship between willingness to pay and product-evoked emotions was investigated using a one-way MANOVA.

5.6.2. A new approach for sensory profiling of wines with consumers using Rate-all-that-apply (RATA) methodology

Describing and quantifying the complex sensory properties of foods and beverages can be an elaborate, time-consuming and expensive task. For this purpose, researchers normally resort to Descriptive Analysis (DA). Alternative rapid methods, that produce just as reliable sensory profiles in shorter time are sought however, to enable linking this sensory data with for e.g. production processes, flavour chemistry or consumer liking information to identify underlying explanatory factors driving the flavour of wine and its liking. Furthermore, due to time, economic and logistical constraints, the wine industry often rely on wine-experts' opinions which, though suited for some scenarios, are potentially biased, less objective and do not reflect regular consumer opinions.

Traditionally, sensory evaluation of food products has been divided into two method groups: analytical tests, where trained individuals or panels are used to objectively evaluate sensory properties; and hedonic tests, where consumers are used to determine acceptance and preference (Lawless & Heymann, 2010; Stone & Sidel, 1993). However, contradictory to the traditional view, current research suggests that naive consumers can be engaged to assess and quantify the sensory attributes of food and beverage products when given a suitable methodology (Moussaoui & Varela, 2010). This would have the added benefit of being able to understand the profile of a wine in the eyes of the consumer, permitting researchers and producers to understand their sensory perceptions and in their language.

A broad range of methods have been proposed for naive consumers to profile a wide range of products, including Napping®, Free Choice Profiling, Flash Profiling, Check-All-That-Apply (CATA), and Rate-All-That-Apply (RATA) (Delarue, 2015; Moussaoui & Varela, 2010; Valentin, Chollet, Lelièvre, & Abdi, 2012). After an extensive literature review and a preliminary trial comparing DA and Rate-all-that-apply (RATA), RATA was identified as the most promising method to use naïve consumers to characterise sensory properties of wines. RATA has been successfully used on a range of food products however, its suitability to profile complex products like wines has not been studied or proven. For this reason, 2 studies comparing RATA with naïve consumers and DA (which is regarded as the gold standard method for sensory profiling) with highly trained panellists were conducted.

Study 1 refers to preliminary work comparing the discrimination ability of RATA undertaken by consumers, compared to traditional DA methodology, in which the attribute lists remain the same for both methods, and assessment is based on a small set of red table wines (i.e. 6 wine samples, of 6 varieties). Study 2 aimed to further elucidated the discrimination ability of RATA using consumers compared to traditional DA methodology, and expands on Study 1 by increasing the number of samples assessed (i.e. 12 white table wines, 6 varieties) and by varying the vocabulary between methodologies.

RATA is a rapid and rather simple method focused on consumers (but can be used by any type of panellist). Participants are presented with a set list of attributes and should only rate the intensity (strength) of the attributes they can perceive (as opposed to all those listed) on a scale. In essence, it is an extension of the widely used check-all-that-applies (CATA) with intensity ratings. Study 1 with 84 naïve consumers used an attribute list that was derived from a previously conducted DA. Study 2 with 71 naïve consumers used a generic attribute list based on the aroma wheel developed at U.C Davis by Ann C. Noble (1987) covering a wind range of typical white wine aromas. The results of the RATA were compared with results from a descriptive analysis (DA) (following the procedure outlined in section 5.3).

5.6.3. How wine description information influences consumers expectations and perception of Australian white wines

This study investigated how information, typically presented on wine producer web sites, wine back-labels, or wine menus, influences consumers' expectations, liking, wine-evoked emotions and willingness to pay for Australian white wines. Regular white wine consumers (n=126) evaluated the same set of three commercially available white wines under three information conditions blind (no information provided), basic (sensory description of the wines) and elaborate (sensory plus quality and winery information). The aim of the basic descriptions was to objectively communicate the sensory properties of the wine. To achieve this a descriptive analysis with 11 trained panellists was conducted to objectively profile the sensory characteristics of the wine. Based on these profiles two wine experts one a wine marketer, experienced in writing wine back labels and wine descriptions, developed the basic wine descriptions. The intention of the elaborate descriptions was to describe the wines in a more detailed and emotive way. To achieve this, the same wine experts described the sensory characteristics in a more vivid manner and also incorporated aspects highlighting the high

quality of the associated wines and favourable background information of the winery into the elaborate wine descriptions. Before the actual consumer testing the descriptions were further refined based on consumer feedback from a focus group panel.

The consumer tasting took place in the sensory laboratory of the University of Adelaide and was split in two sessions, which were at least one week apart. Consumers rated expected wine liking after reading the information and before tasting; and liking, wine-evoked emotions (measured with a 19-item wine-specific AWEEL emotion lexicon) and willingness to pay after tasting each sample. In the first session, consumers evaluated the wines under blind conditions (no information presented). In the second session, the same wines were presented together with the basic or elaborate descriptions. In each session, wine samples (30 mL) were presented in standard ISO glasses at 12-13°C, randomised and coded.

5.6.4. Cross cultural wine consumer wine flavours, emotions and occasion survey

To investigate consumers' wine flavour preferences and associations with situations in international markets, an online survey with the following aims was conducted in Australia, UK and USA: i) identify any differences in aroma liking/disliking and emotional responses between three English-speaking countries); ii) identify emotions that may be related to specific wine aromas and iii) investigate which aromas in wines were preferred by wine consumers in different contexts and meteorological seasons.

In total 3000 regular wine consumers, 1000 from Australia, UK and USA each, completed the online survey. The participants were recruited through Research Now (Sydney, NSW) an international market research company which is ISO 20252 certified for quality in market research. For consumers to participate they had to fulfil the following criteria by being of legal drinking age (older than 18 years in Australia and UK, and older than 21 years in the USA) and consume wine at least once a month. After pretesting at the University of Adelaide with students and staff of Australian, British and US-American background the survey was administered using Survey Monkey^{tm} (Marketing Research Surveys, USA).

The survey consisted of 5 sections described below and it took participants between 15 to 25 min to complete.

Section 1: Measured consumers' involvement in wine, and their typical alcoholic beverage consumption behaviour.

Section 2: To determine consumers' liking for wine aromas, they were asked to rate their liking/disliking of 59 aromas commonly found in red and white wines (per the Australian Society of Viticulture and Oenology tasting guide). The 59 aromas were presented based on similarity in 9 groups. One aroma from each group which was considered by researchers as the most frequently found aroma in wines, was selected as the representative for this group. For example, 'strawberry' was the selected representative for the group that contained 'blackcurrant', 'strawberry', 'blackberry', 'blueberry', 'cranberry', 'raspberry' and 'mulberry'. The other group representative aromas were 'mint', 'chocolate', 'confectionary', 'passionfruit', 'pepper' (black or white), 'lemon', 'rose' and 'barnyard'. For those selected 9 aromas, respondents also answered the following question *'please indicate your level of liking/disliking for the following aromas:'* to allow discrimination of liking/disliking of an aroma in general and specifically in wines.

Section 3: For each of the 9 aromas, respondents indicated how strongly a selected aroma in wine made them feel a set number of emotions using a GEOS 9-item scale (Chrea et al., 2009).

Section 4: This section aimed to investigate if different aromas are more suitable/preferred for certain consumption occasions and seasons. Respondents were asked to indicate their preferences for the selected 9 aromas in different seasons (spring; summer; autumn; winter; anytime, the season does not matter to me; never, I do not like it) and in different contexts (at home; during a romantic dinner in a restaurant; at a party/BBQ with family and friends; anywhere, a place does not matter to me; never, I do not like it) by selecting only one category in each question.

Section 5: The last section included general demographic questions such as gender, age, highest education and household income.

Data was analysed with a combination of Analysis of Variance (ANOVA) and Principal Component Analysis (PCA)

5.6.5. Wine flavours: elicitation of emotional responses and influences on wine consumers' perception of wine quality, preference and purchase decisions

Two consumer trials were conducted to examine the influence of wine flavour and context on acceptance and emotions. Study 1 investigated the influence of 5 typical white wine flavours i.e. citrus, fruity, floral, green, and oak. Study 2 investigated the effect of floral and green flavours on consumers' perception of Cabernet Sauvignon wines in two environmental contexts.

Flavour study 1: White wines

Based on the survey results (as described in section 6.2.1), five flavours were selected to prepare wines for the consumer wine tasting including highly desirable citrus, fruity/tropical and oaky/vanilla flavours, moderately desirable flavour of floral and less desirable flavour of green. To produce five wines with these flavours without altering other parameters, a neutral, unoaked Chardonnay was chosen as base wine and spiked with food-grade flavour compounds. The optimal compounds and their concentrations for spiking were co-created in an iterative process with consumer input. Throughout this process a combination of 2 compounds were identified to be most suitable to produce the desired flavour/aroma characteristics. A DA (n=11) of the flavoured wines confirmed that the selected flavours were clearly perceivable in the spiked wines without significantly changing other taste perceptions. The final set of spikes and their concentration is summarised in Table 3.

Table 3: Flavour compounds and their concentrations used to produce the spiked white wines.

Flavour	Aroma compound 1	mg/L	Aroma compound 2	mg/L
Citrus	Citral	0.5	Limonene	5
Fruity	Isoamyl acetate	10	Ethyl hexanoate	2
Floral	Geraniol	5	Phenethyl alcohol	150
Green	*cis*-3-Hexen-1-ol	2	Hexanal	2
Oak	Vanillin	1	Oak lactone	0.25

All compounds were sourced from Symrise AG in food-grade quality and are registered as flavouring compounds and are authorized to be used in all categories of flavoured foods.

During the consumer tasting, 113 regular white wine consumers evaluated liking and product-evoked emotions (using the developed AWEEL emotion lexicon) by blind tasting the five spiked samples plus the base wine under standardised conditions in the sensory laboratory of

the University of Adelaide. 30 ml samples were presented sequentially one at a time, in randomised order and in coded clear ISO glasses at 14-15°C.
A standard ANOVA approach was used for data analysis.

Flavour study 2: Red wines

This study extends on the white wine study by including consumption context as an additional factor. To study the influence of specific red wine flavours, in this case floral and green (respectively liked and disliked in Cabernet Sauvignon in earlier Australian wine consumer studies) and consumption context, a 2 wine by 2 room design was used. Commercial Cabernet Sauvignon wine was used as base-wine and spiked with 200ng/L 3-isobutyl-2-methoxypurazine to increase green flavour characteristics. To increase floral characteristic of the base-wine 1.2mL/L rose water was added. The consumer wine tasting with 105 regular red wine consumers took place in two differently decorated rooms; 1) with orange interior (chairs, table cloths etc.) and floral arrangements and 2) with green interior and green plants laid out through the room (Figure 1). Consumers tasted three wines (the 2 spiked wines with enhanced green and floral aromas, and the base-wine as control) in each room and evaluated the flavour intensity of green and floral character, liking of samples, and emotions elicited using the AWEEL emotions list. The order of rooms for evaluation were randomised across participants. Samples were presented coded and randomised in clear ISO glasses at room temperature.



Figure 1: Context environment with floral arrangements (left) and green pot plants (right).

5.6.6. Consumer understanding and perception of wine mouthfeel and elicitation of emotions

Wine mouthfeel is a tactile (touch) sensation that occurs in the mouth during wine consumption. It encompasses sensations such as astringency (roughing and drying), viscosity (thickness), body (palate weight) and warmth (as in tasting high alcohol spirit type beverages)

among others (Jackson, 2009), which are major contributors to the sensory perception of wine (Gawel, Oberholster, & Francis, 2000; Pickering & Demiglio, 2008). The current project intended to gather more detailed insights of consumers' understanding and perception of the mouthfeel sensations of wine body and astringency. More specifically, the conducted studies had two main aims: 1) determine the effects of the intrinsic mouthfeel sensations of astringency and wine body on consumers' wine liking and wine-evoked emotions, and 2) investigate the consumers understanding of the term wine body. To achieve this aims a consumer wine tasting and an online consumer survey were conducted.

Consumer wine tasting

A two astringency level × two body level factorial design was used to investigate consumers' perception of astringency and wine body in wine. This formed part of a Masters of Viticulture and Oenology by course work student's 6 month research project. Addition of grape seed extract (GSE) was used to alter astringency and xanthan gum to alter wine body. Prior to the consumer tasting the levels of xanthan gum and GSE were determined with a directional paired comparison test of wines with GSE or gum added against a wine with no added mouthfeel agents using experienced assessors (n=30). Wines were significantly fuller in body ($p<0.05$) and more astringent ($p<0.01$) at 0.35g/L gum and 1.5g/L GSE, respectively. To ensure these characteristics were noticeable for regular consumers, gum and GSE were used at 0.5g/L and 2g/L, respectively, for the trial. The final samples presented to the consumers were; a wine with added xanthan gum (0.5 g/L), a wine with added GSE (2.0 g/L), a wine with added gum and GSE, and a control with no added gum or GSE. Samples were prepared using a Semillon dry white base wine that was carbon treated to reduce aroma. Consumers (n=112), who regularly drank white wine (at least once per month), were recruited by advertisement in a local newspaper from around the Adelaide area. Testing was conducted in individual booths. Samples (30 mL) were presented in black INAO glasses (to mask potential biases due to changes in appearance caused by the addition of GSE and xanthan gum) at 20°C and coded with three digit codes. For each wine, consumers were instructed to first taste and rate their liking followed by rating the intensity of 19 emotions using the AWEEL lexicon.

Online survey

To determine the consumer understanding of the term wine body and the types of sensory intrinsic characteristics associated with it from a consumers' perspective, an online survey was conducted. This work was conducted with the assistance of a French student intern and in

collaboration with another post-doctoral fellow not funded from the current project. The online questionnaire was presented with SurveyMonkey® and gathered the following information;

- basic demographic information and the consumers' level of wine expertise,
- the importance consumers place on selected intrinsic sensory characteristics of wine for wine quality,
- consumers were asked if they use the word "body" to describe wines and how they wold describe wine body in their own words,
- consumer assignment of the level of wine body (*light-bodied, medium-bodied, full-bodied)* to a wide range of different wine styles.

In total, 136 regular wine consumers completed the online survey. The consumer sample covered a wide range of age groups between 18 and 60+ with a balanced gender distribution. For data analysis, a combination of descriptive and inferential statistics was applied including ANOVA and Friedman's test. The open-ended questions were analysed with Wordstat® (Version 7.1 Provalis Research, Montreal, Quebec) following the procedure outlined by Le Fur et al. (2013) and Vidal et al. (2015); stop words such as "the" and "a" were removed, spelling mistakes were corrected and synonymous words grouped together. The final groups were analysed with frequency analysis to determine the percentage of consumers who used the different terms to qualify wine body.

6. Results/Discussion

6.1. Investigation of the nature of the intrinsic sensory wine drivers behind wine consumers' perception of wine.

6.1.1. Relationship between chemical composition, expert and consumers' perception of Shiraz wine quality

Looking at the entire population level, the gold medal wines were liked most in all three trials and a clear trend could be found for trial 2 and 3 (Figure 2 and Table 4). In trial 1 the "No medal" wine was rated better than bronze and silver medal wines. Investigating this effect in more detail it was found that this wine had a higher concentration of residual sugar and was especially liked by women.

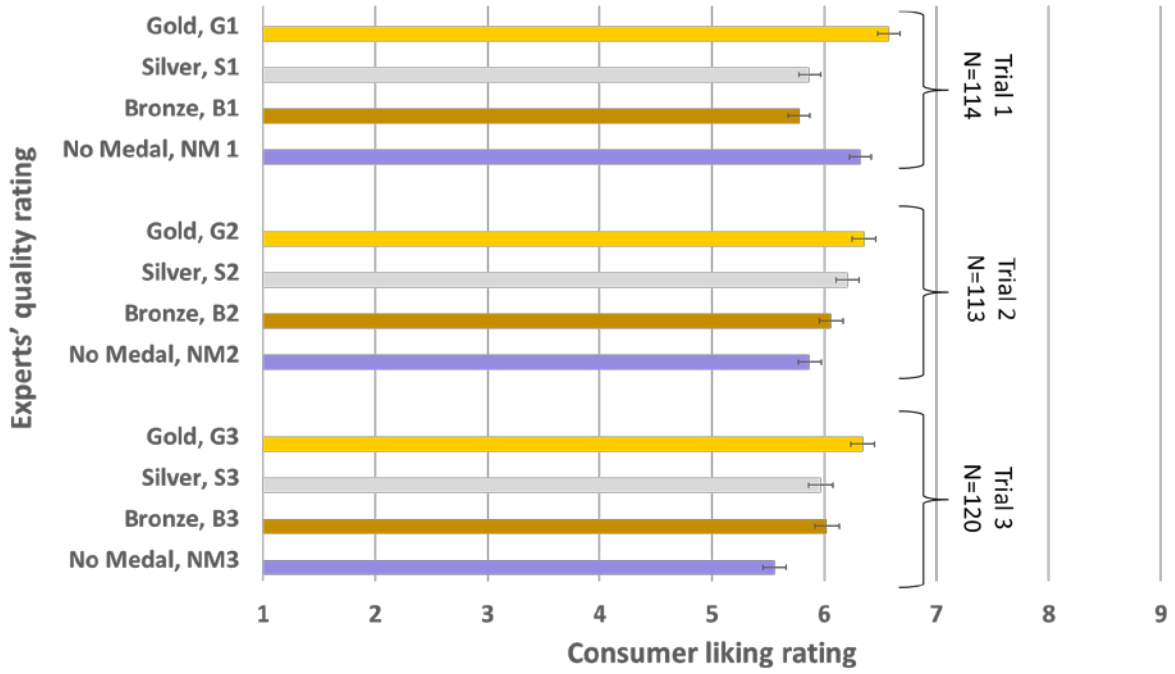


Figure 2: Relationship between experts' quality rating and consumer liking in all three trials. Liking was rated on a 9-point hedonic scale (1 – dislike extremely to 9 – like extremely). Error bars indicate SE.

Table 4: Table 1: Consumers' rating of quality (1 – low to 5 – high quality). A, B, C indicate significant differences p < 0.05.

	Wine	Consumer quality*	
		Mean	Sig. diff
Trial 1	Gold, G1	2.8	A
	Silver, S1	2.5	BC
	Bronze, B1	2.4	C
	No Medal, NM 1	2.6	B
Trial 2	Gold, G2	2.7	A
	Silver, S2	2.5	B
	Bronze, B2	2.5	B
	No Medal, NM2	2.4	B
Trial 3	Gold, G3	2.7	A
	Silver, S3	2.5	B
	Bronze, B3	2.6	AB
	No Medal, NM3	2.3	C

Investigating the relationship between sensory attributes, volatile compounds and wine quality, the results showed that the sensory attributes allowed a good differentiation between Shiraz wines rated as high and low quality by the experts (Figure 3). The differentiation was less clear for the medium and medium-high quality graded wines.

Gold medal wines were perceived as more complex, rich in chocolate, wood, vanilla, savoury, spice, with more apparent tannins, fuller bodied and higher overall aroma intensity (Figure 3). In comparison wines rated as no medal quality were described as intense in confectionary and red fruit aroma, and low in overall aroma intensity and complexity. Silver and bronze wine ranged in between the gold and no medal wines.

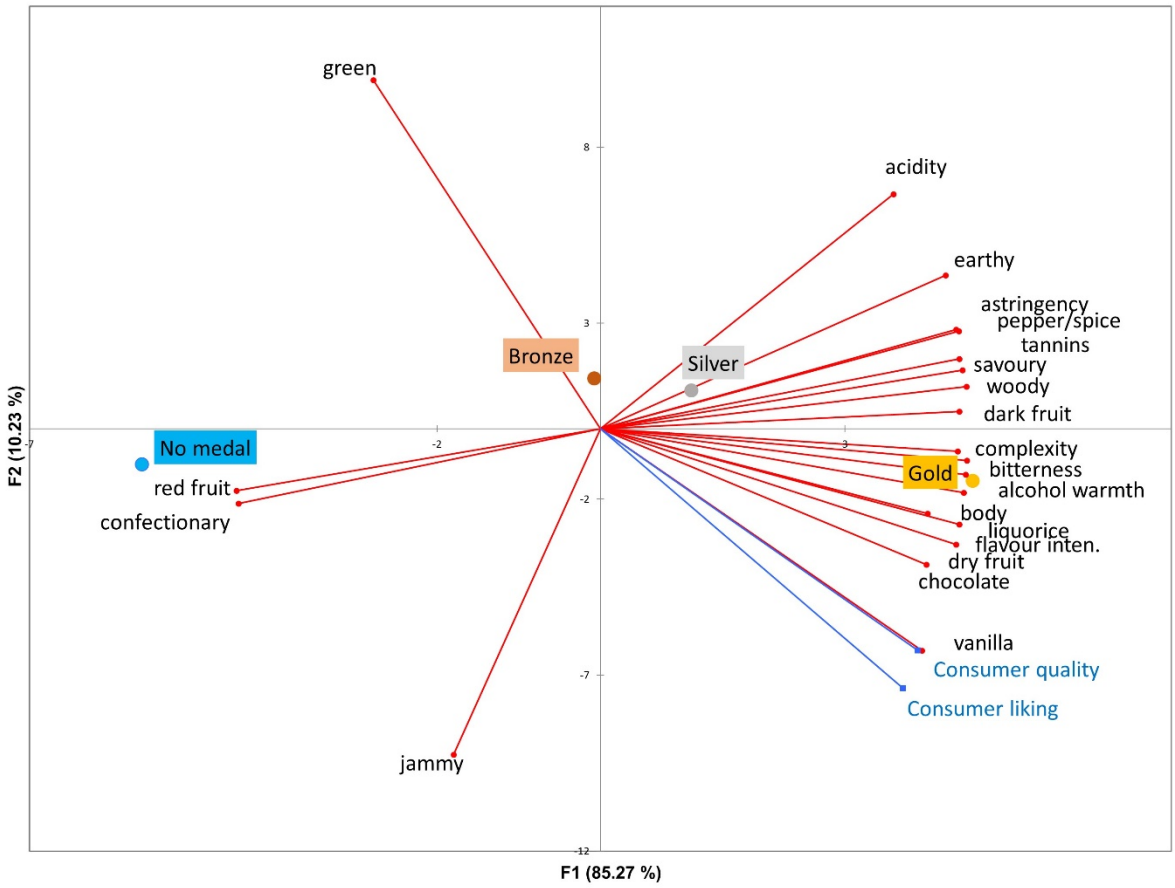


Figure 3: Biplot of the product space with significant descriptors retrieved from the descriptive analyses. Only descriptors perceived on the palate are shown to keep the plot clear as they are highly correlated with the aroma descriptors. Consumer quality ratings and liking were added as supplementary data.

These results are supported by the chemical analyses. High quality gold medal wines are highly correlated with Oak lactones (sweet oak, vanilla, coconut), eugenol (clove, spicy), β-ionone (blue flowers, fruity), guaiacol (smoky) and aged/oxidative (nonanal) characteristics, whereas the low quality wines (no medal) were opposite, and associated with compounds with artificial fruit characteristics (isobutanol and isoamyl acetate) and rose (phenylethyl alcohol) (Figure 4). Silver and bronze medal wines were more associated with fruity esters (red and dark berries) and less oak and other complexing compounds (e.g. nonanal, β-ionone, ethyl butanoate) compared to gold medal wines.

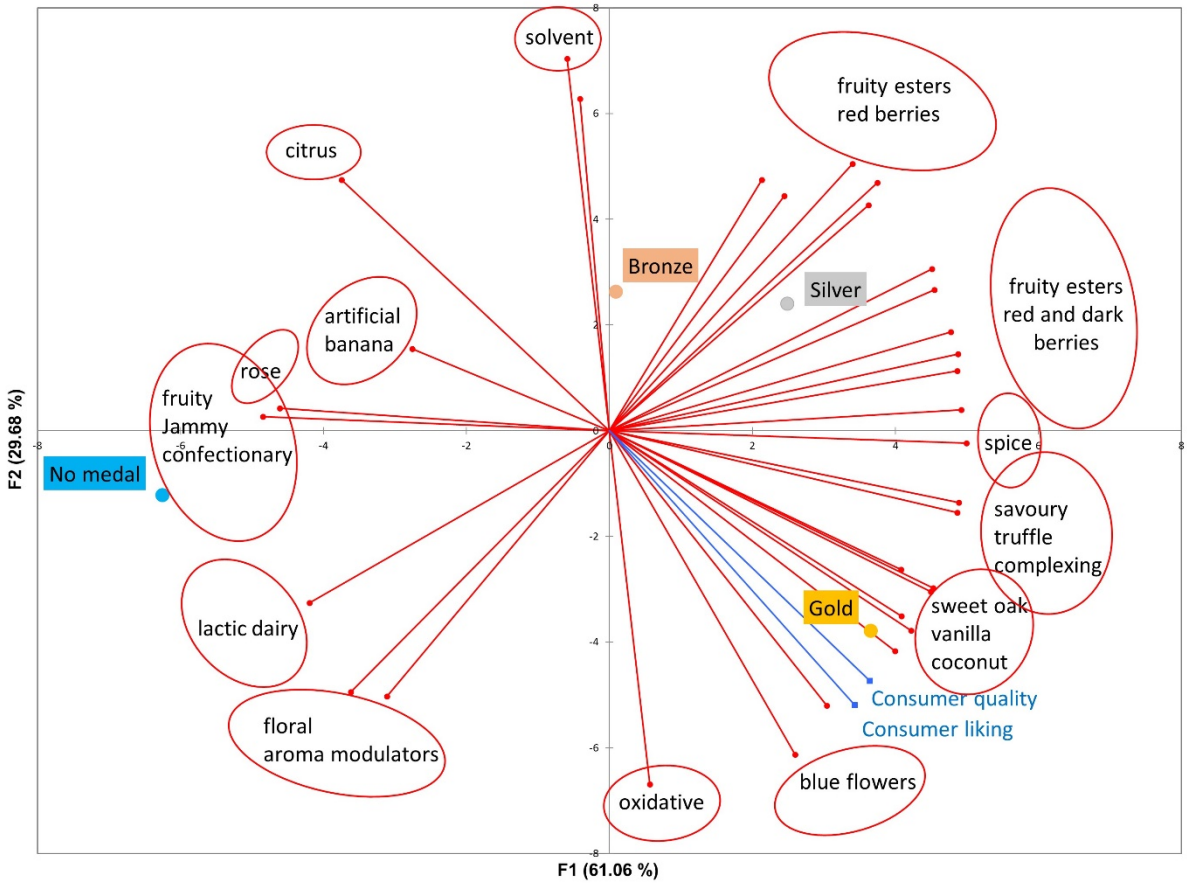


Figure 4: Biplot of the product space with significant volatile compounds with Odour Activity Values (OAV) > 1. Consumer quality ratings and liking were added as supplementary data.

In conclusion, this study showed that:

- Even though individual preferences were very different there seems to be general consensus between consumers and experts on quality ratings/liking. Especially for the gold/high quality wines, but did not fully align for the intermediate quality. Silver and bronze rated wines were liked similarly and no difference in quality perception of the consumers was found.

- A clear differentiation between high and low quality Shiraz wines could be made by sensory characteristics and volatile compounds. Oak flavour, complexity, body, and overall flavour intensity were identified as sensory drivers for consumers‘ and experts‘ quality perception of Australian Shiraz. The chemical composition of the wines strongly supports these findings.

6.1.2. Prediction of phenolic composition of Shiraz wines using Attenuated Total Reflectance Mid-Infrared (ATR-MIR) Spectroscopy

A manuscript base on this study has been published in the American Journal of Enology and Viticulture: Ristic, R., Cozzolino, D., Jeffery, D. W., Gambetta, J. M., & Bastian, S. E. P. (2016). Prediction of phenolic composition of Shiraz wines using attenuated total reflectance mid-infrared (ATR-MIR) spectroscopy. 67, 460–465.

One hundred commercial Shiraz wines from 24 Australian wine regions were assigned into four quality levels (gold, silver and bronze medals, or no medal) by an expert panel based on intrinsic wine attributes such as colour, aromas, flavours, and mouthfeel properties. Wine colour density and phenolics composition were measured by modified Somers measurements and by an attenuated total reflection (ATR) mid-infrared (MIR) spectroscopy. Principal component analysis (PCA) and Partial least squares (PLS) regression analysis were performed to evaluate the use of ATR-MIR as a rapid analytical technique to predict red wine phenolic parameters and consequently wine quality.

When measured by standard techniques (i.e. modified Somers' measurements) wine colour density (WCD, sum of pigments absorbing at 420 nm and 520 nm), wine hue (ratio of absorbance at 520 nm and 420 nm), SO_2 resistant pigments (a measure of stable, non-bleachable, red wine colour) and total phenolics (based on absorbance at 280 nm) showed highly significant correlations with wine quality level and retail price (Table 5). The results demonstrated that wines with higher WCD had greater concentration of phenolic compounds, and consequently received higher quality scores.

Table 5: Correlation between quality category and retail price with the wine colour and phenolic measurements. r stands for correlation coefficient.

Phenolic parameters	Quality category		Retail price	
	r	p-value	r	p-value
Wine colour density	**0.50**	**<0.001**	**0.44**	**<0.001**
Wine hue	**-0.16**	**0.01**	**0.24**	**<0.001**
Anthocyanins	0.10	ns	**-0.31**	**<0.001**
SO_2 resistant pigments	**0.38**	**<0.001**	**0.37**	**<0.001**
Total phenolics	**0.36**	**<0.001**	**0.40**	**<0.001**

The ATR-MIR spectra contained relevant functional group information related with the wine colour parameters. Most of the variation occurred in the region between 1600 and 1100 cm^{-1}, indicating that the differences in wine sample composition could be detected in this 'fingerprint' region (Figure 5). Moreover, the PLS loadings indicated that regions 1100 to 1000 cm-1, associated with aromatic, C-C and C-C-O functional groups that are related to different phenolic compounds present in red wines, were the most important in order to explain the calibration models for the colour and phenolic parameters analysed.

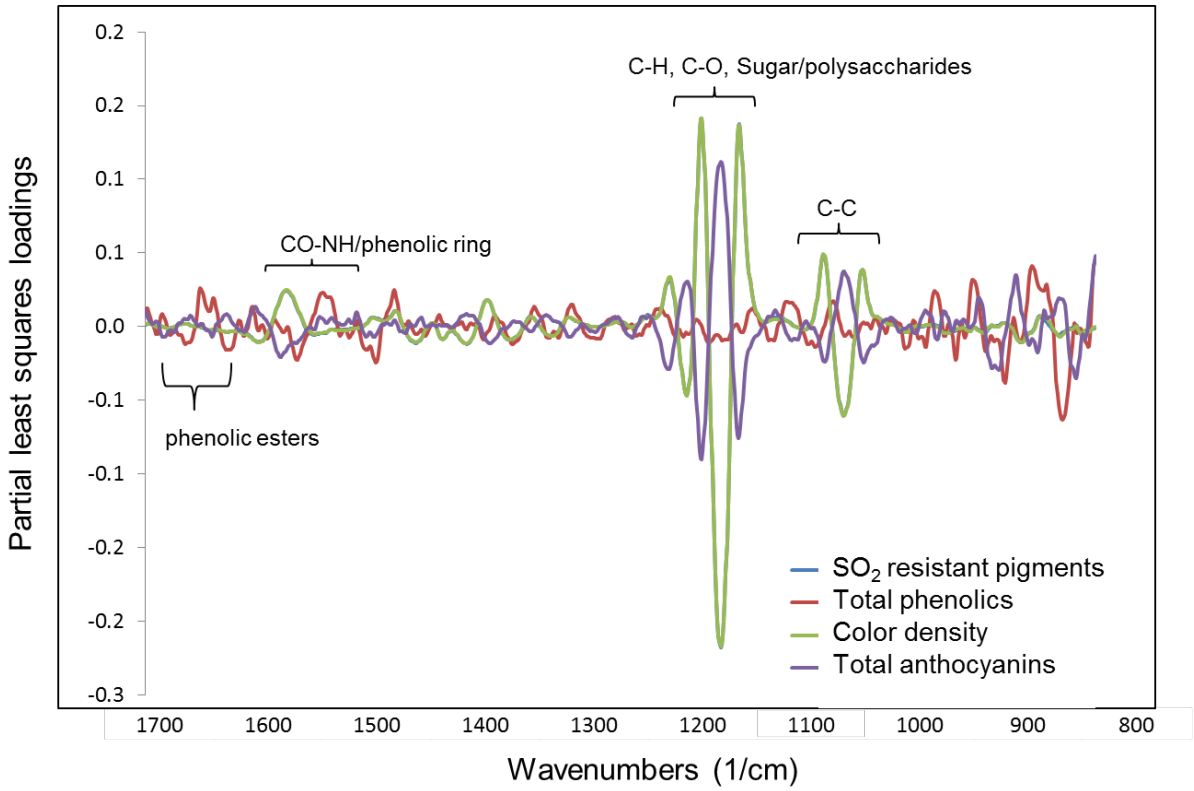


Figure 5: Partial least squares loadings derived from the calibration models (second derivative or MIR spectra in the fingerprint region, showing tentative functional group assignments).

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The score plot of the first two principal components (PCs) obtained from the ATR-MIR spectra is shown in Figure 6. Based on the PCA plot some separation based on wine quality can be observed. Gold medal wine mainly group together in the bottom right quadrant were no-medal wines tend to have more extreme loadings (further away from the centre). This indicates that MIR spectra contain information not only associated with specific composition characteristics such as sugar or phenolics of wines, but also about their quality (as assigned by experts).

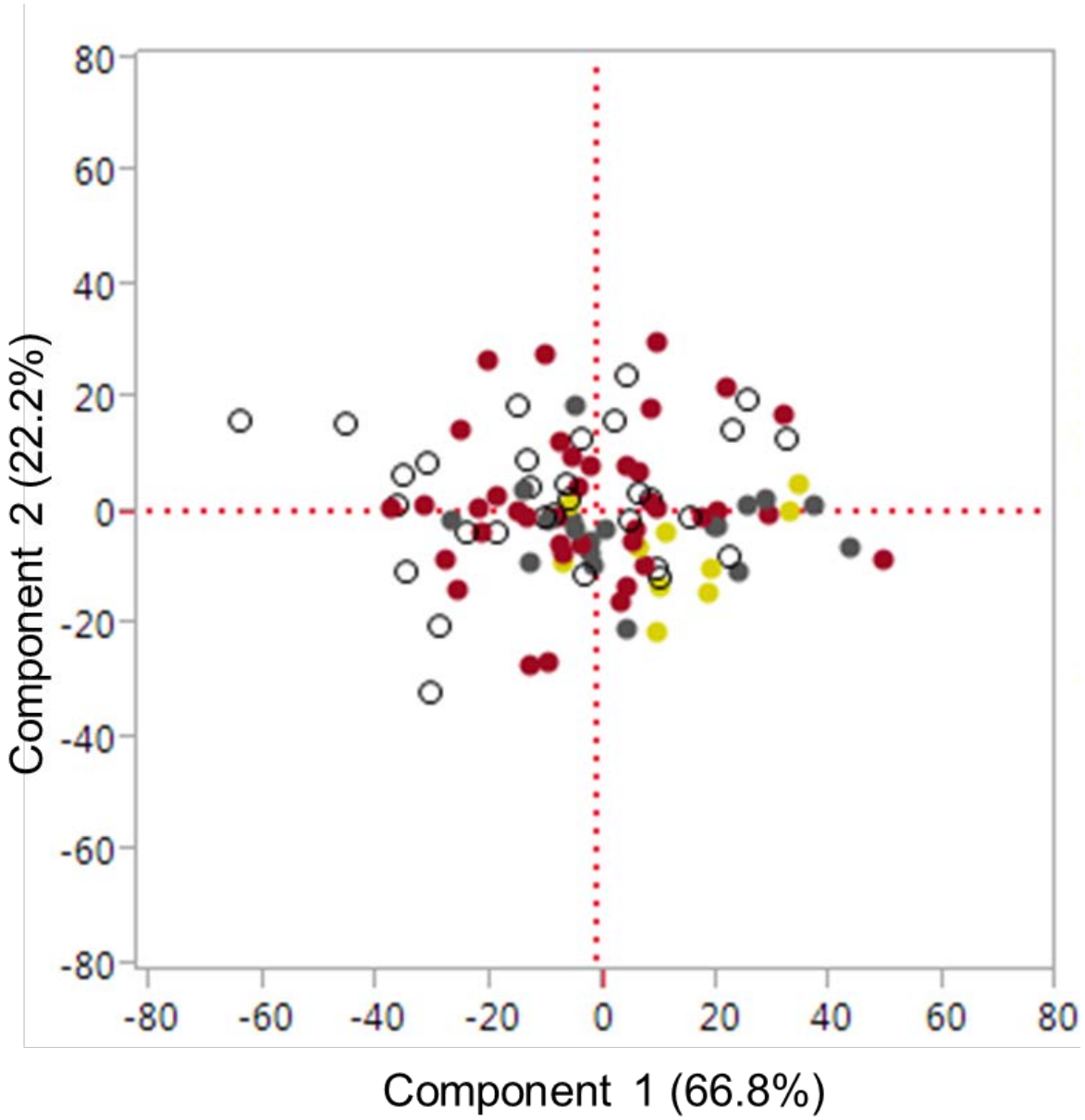


Figure 6: Principal component score plot of 100 Australian Shiraz wines analysed using ATR-MIR fingerprint region (1700 – 800/cm). Quality levels were assigned by the expert panel based on the Australian 20 point wine show scoring system as follows: ● = gold medal, ● = silver medal, ● = bronze medal and ○ = no medal.

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In conclusion, this study showed that:

- colour and usual red wine phenolics measures (e.g. wine colour density, wine hue SO_2 resistant pigments and total phenolics) showed strong positive correlations with wine quality level and retail price,
- ATR-MIR spectroscopy in combination with PLS regression as a rapid method to measure important parameters related to red wine phenolic composition and wine quality,
- however, more wine samples would be necessary with extended range of phenolic compositions to improve MIR calibration robustness, specificity and accuracy.

6.1.3. Comparing consumers capabilities to profile wines using Rate-All-That-Apply (RATA) with a trained Descriptive Analysis (DA) panel

A manuscript base on this study has been has been published in the American Journal of Enology and Viticulture Danner, L., Crump, A.M., Croker, A., Gambetta, J.M., Johnson, T.E., Bastian, S.E.P., 2018. Comparison of Rate-All-That-Apply (RATA) and Descriptive Analysis (DA) for the sensory profiling of wine. 69, 12–21.

Contrasting to the traditional view in sensory science, more recent research suggests that naïve consumers are well capable to assess and quantify the sensory attributes of food and beverage products when given a suitable methodology. Further, more rapid methods to generate objective sensory profiles of wines are required to replace existing expensive and time-consuming techniques for research and industry.

Over the course of two studies, we aimed to compare the discrimination ability and wine sensory alignment similarity of RATA and DA for a wide range of wine samples.

Comparison of discrimination ability between RATA and DA

Study 1 used the same wine sensory attribute list for the DA and the RATA approach, which allowed a direct comparison of discrimination ability by comparing the number of significantly discriminating attributes. The results (Table 6) show that 40 out of 43 (93%) attributes were significantly discriminating between samples. The RATA approach resulted in very similar results, where 42 out of 43 (98%) were significantly discriminating between the presented samples.

In Study 2 the attribute lists were different between RATA (using a generic attribute list for white wine) and DA (using a panel specific list), therefore it is only possible to directly compare the discriminative ability for the 16 shared attributes. Out of these 16 attributes, 12 were discriminative for the DA (75%), whereas 14 (88%) were significantly discriminating between samples using the RATA approach. These results confirm the results of Study1 and suggests that naïve consumers using RATA discriminate similarly between samples as a trained panel (DA).

Table 6: Summary of results for the comparison of sensory profiles obtained with RATA and generic DA for Study 1 and 2. ** indicate significant differences at p<0.01, * at p<0.001.**

	Study 1		Study 2	
	RATA	DA	RATA	DA
Number of terms	43	43	52	32
Average number and percentage of terms used	26 (60%)	n.a.	30 (57%)	n.a.
Number and percentage of terms with sig. differences (p<0.05)	42 (98%)	40 (93%)	40 (77%)	29 (91%)
Percentage of variance explained by the first two dimensions of the PCA	97%	97%	76%	82%
RV between sample configuration obtained from DA and RATA	0.974**		0.921***	

Comparison of sensory alignment similarities between RATA and DA

After confirming that RATA and DA can result in comparable discrimination abilities, the next task was to investigate if the attributes were used in a similar way to describe the samples. To achieve this the sample and attribute configurations were compared in two ways: i) visual comparison of the sample and attribute alignment within the multiple factor analysis (MFA) plots, and via ii) statistical quantification of the similarities in sample configurations using examination of RV coefficients. The RV coefficient is a statistical measure that indicates the closeness between two sets of points (in this case samples from DA and RATA) that are each represented in the matrix (multivariate sensory space).

Visual inspection of the biplots (Figure 7 and Figure 8) resulting from the MFA show high similarities between RATA and DA methods for both studies. In case of Study 1 (Figure 7) a clear separation between oaked and unoaked samples was found in the first dimension. Attributes related to oak treatment (e.g. sweet oak, leather, spice and savoury) clustered in the top left quadrant. Likewise, mouthfeel attributes including alcohol/heat, astringency and body

are grouped in the bottom-left quadrant together with taste attributes (such as acidity and bitterness) and berry characteristics. Tropical, fruity, honey, floral and sweet taste clustered on the right-hand side. The separation by consumers using the RATA method strongly aligns with the DA panel assessment, demonstrating that in this instance consumers were able to separate samples based on processing conditions (i.e., oak maturation), wine style (i.e., full bodied, dry red table wine versus rosé styles) and typical varietal characteristics.

Similar agreement between RATA and DA results were also found in Study 2 (Figure 8). The wines were separated into four distinct groups based primarily on grape variety. Green and tropical attributes were clustered on the top left hand side of the plot separating Sauvignon Blanc samples from the other wines. Oak-related attributes (e.g., woody, nutty, and spice) were grouped in the top right quadrant and associated with the Chardonnay and Viognier samples, separating between wines based on production methods. Acidity related attributes grouped together with apple, citrus and floral attributes in the bottom left quadrant, aligning with the varietal characteristics of Riesling, Gewürztraminer and Semillon. An interesting finding is that there is a high agreement even between less common descriptors such as chemical and medicinal in the bottom right quadrant, furthermore consumers have used the term floral to correctly differentiate Gewürztraminer wines from the other samples.

Highly significant RV coefficients of 0.97, $p<0.01$ and 0.92, $p<0.001$ were found for Study 1 and 2, respectively (Table 6). This statistically confirms the high visual agreement between RATA and DA results for both studies.

In conclusion, these two studies showed:

- that the RATA method with naïve consumers can result in very similar sample discrimination and sample configuration as DA with trained panellists, when evaluating commercial wine samples,
- suggesting that RATA can be a valid, less expensive and rapid method for sensory profiling of wines for both industry and research applications, making it particularly interesting when additional consumer responses (e.g. hedonic ratings or willingness-to-pay) are of interest and/or resources and technical skills are limited.

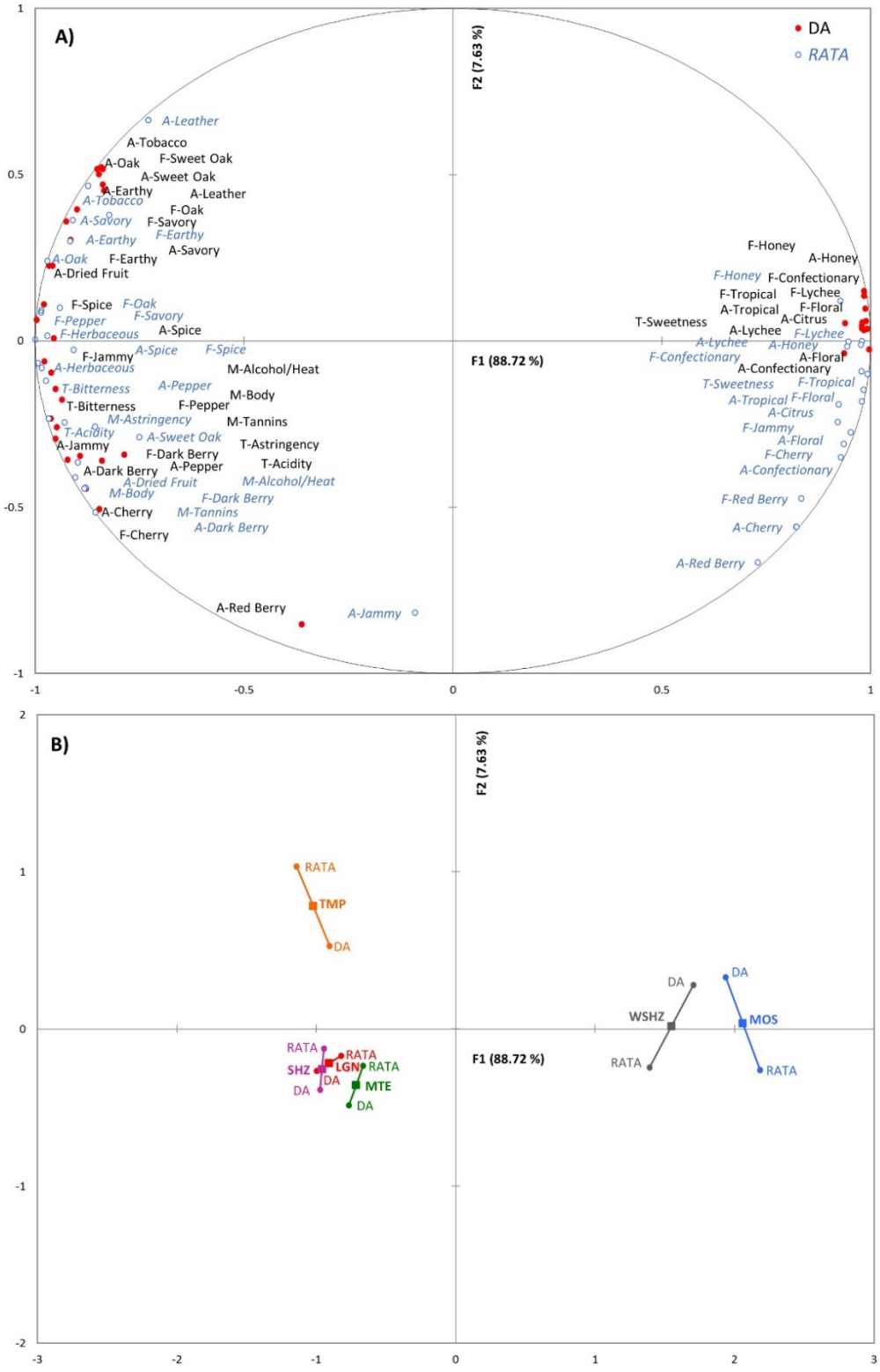


Figure 7: Representation of the A) significantly discriminating sensory attributes, and B) samples of Study 1 in the first two dimensions of the MFA performed on the significantly discriminating attributes of the DA with trained assessors and RATA with naive consumers. A = aroma, T = taste, M = mouthfeel and F = flavour. Wine sample abbreviations include TMP = Tempranillo, SHZ = Shiraz, LGE = Lagrein, MTE = Montepulciano, WSHZ = Shiraz rosé, MOS = Moscato, coloured pink with commercial grape skin extract. Adapted from Danner, Crump, et al. (2018) © 2017 American Society for Enology and Viticulture. AJEV

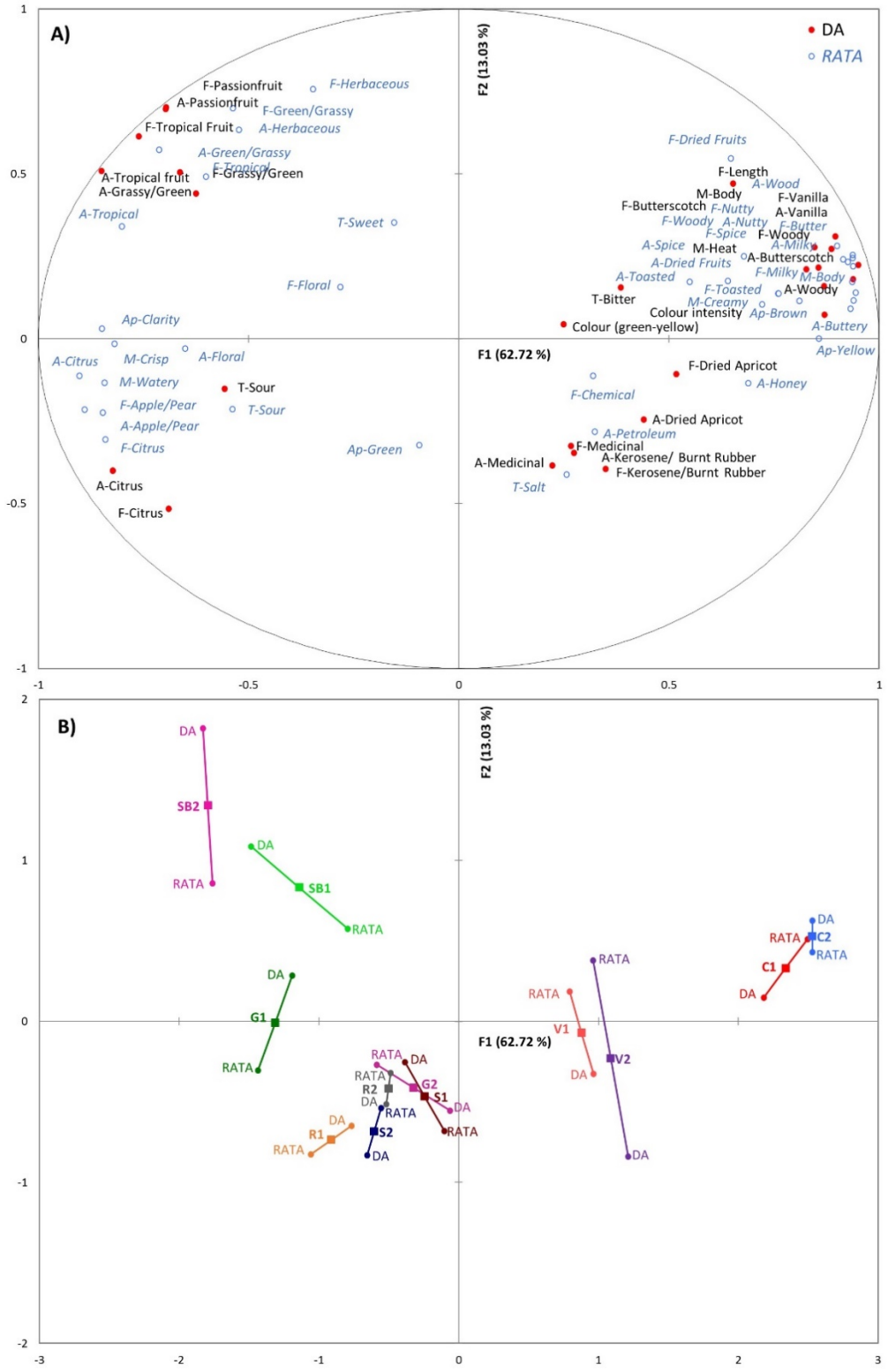


Figure 8: Representation of the A) significantly discriminating sensory attributes and B) samples of Study 2 in the first two dimensions of the MFA performed on the significantly discriminating attributes of the DA with trained assessors and RATA with naive consumers. Ap = appearance, A = aroma, T = taste, M = mouthfeel and F = flavor. C1 & C2 Chardonnay, G1 & G2 Gewürztraminer, R1 & R2 Riesling, S1 & S2 Semillon, SB1 & SB2 Sauvignon Blanc and V1 & V2 Viognier. Adapted from Danner, Crump, et al. (2018) © 2017 American Society for Enology and Viticulture. AJEV

6.2. The influence of context effects on consumer wine quality perception and wine preference ratings

It has been shown that the context in which food products, are presented and consumed can influence consumers perception of the product (e.g. (Cardello, 1995; Hersleth, Mevik, Næs, & Guinard, 2003). Over the course of two consumer studies the effect of:

1) consumption situation and,
2) the level of wine description information presented with the wine

on consumers' perception of commercial Australian wines, elicited emotions and behaviour were examined.

6.2.1. Consumption context effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines

A manuscript base on this study has been published in Food Research International: Danner, L., Ristic, R., Johnson, T. E., Meiselman, H. L., Hoek, A. C., Jeffery, D. W., & Bastian, S. E. P. (2016). Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines. 89, 254–265.

The aims of the study were to examine:

1) whether wine quality influences the consumer emotional response profile and liking of Australian commercial Shiraz table wines and,
2) the influence of consumption context (laboratory, restaurant, at home) on consumers' hedonic evaluation and emotional responses in order to see if the laboratory setting generated similar results.

In total 349 consumers tasted 4 Shiraz samples, one of each of high, medium-high, medium-low and low quality, in three different consumption situations, ranging from a highly-controlled laboratory setting to more realistic restaurant and at-home settings.

Results showed that consumers liked high quality (gold medal) wines more than the lower quality wines (Figure 9). No significant differences in liking were observed between the silver, bronze and no medal wines in any of the three contexts.

No significant effect of consumption situation ($p = 0.739$) or wine quality by consumption situation interactions ($p = 0.058$) on liking were observed, showing that consumers' hedonic evaluation was similar at home, in the lab and the restaurant. This indicates that consumers

might be well aware what they like and not like, and that the data collected in a sensory laboratory can reflect consumer preferences in real-life situations well.

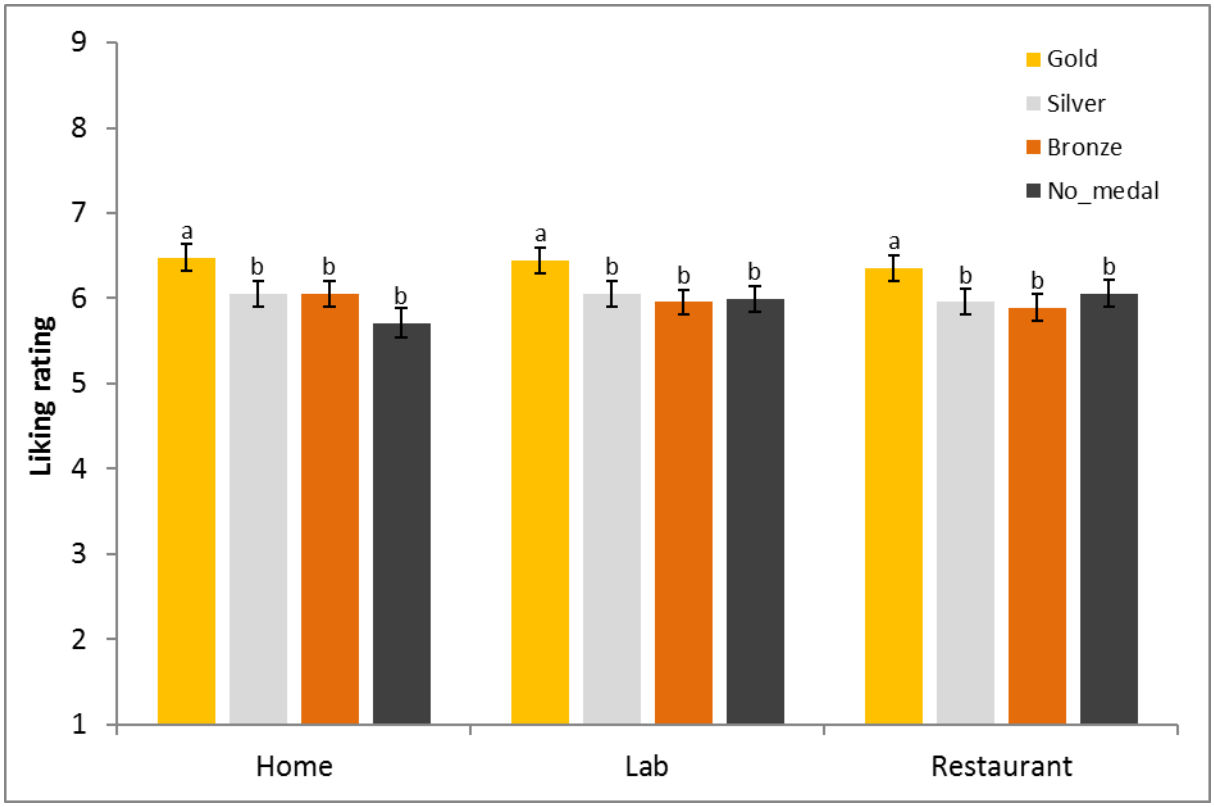


Figure 9: Mean consumer hedonic liking ratings for the four wine quality levels in the three context settings (n = 349; 1 = dislike extremely to 9 = like extremely). a and b indicate significant differences based on post-hoc comparisons using Bonferroni correction ($p < 0.05$). Error bars indicate standard error. Reprinted from Food Research International, Vol. 89, Danner et. al., Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines, 254–265, Copyright (2016), with permission from Elsevier.

The results showed that wine-evoked emotions, opposed to liking, were significantly influenced by wine quality and consumption situation. For *calm*, *contented*, *enthusiastic*, *happy*, *optimistic*, *passionate*, *relaxed* and *warm-hearted* emotions consumption situation effects as well as quality effects were observed. N*ostalgic* and *surprised* were affected by wine quality but not the context. The opposite was the case for a*dventurous* and *tense* emotions, which were influenced only by the context effects.

It was found that gold medal wine evoked more intense positive emotions e.g., enthusiastic, happy and nostalgic compared to lower quality wines. In regard to consumption situation, consumers expressed stronger positive emotions in the restaurant, where social interactions and food consumption was allowed, compared to the rather sterile setting in the sensory laboratory.

The wine-evoked emotion intensity in the “at home” tasting situation, where participants were free to taste the wines in combination with food, in or without company, ranged between the restaurant and the laboratory.

No significant interactions between wine quality and consumption situation were observed, indicating that consumption situation had a similar effect on wine-evoked emotions regardless of wine quality.

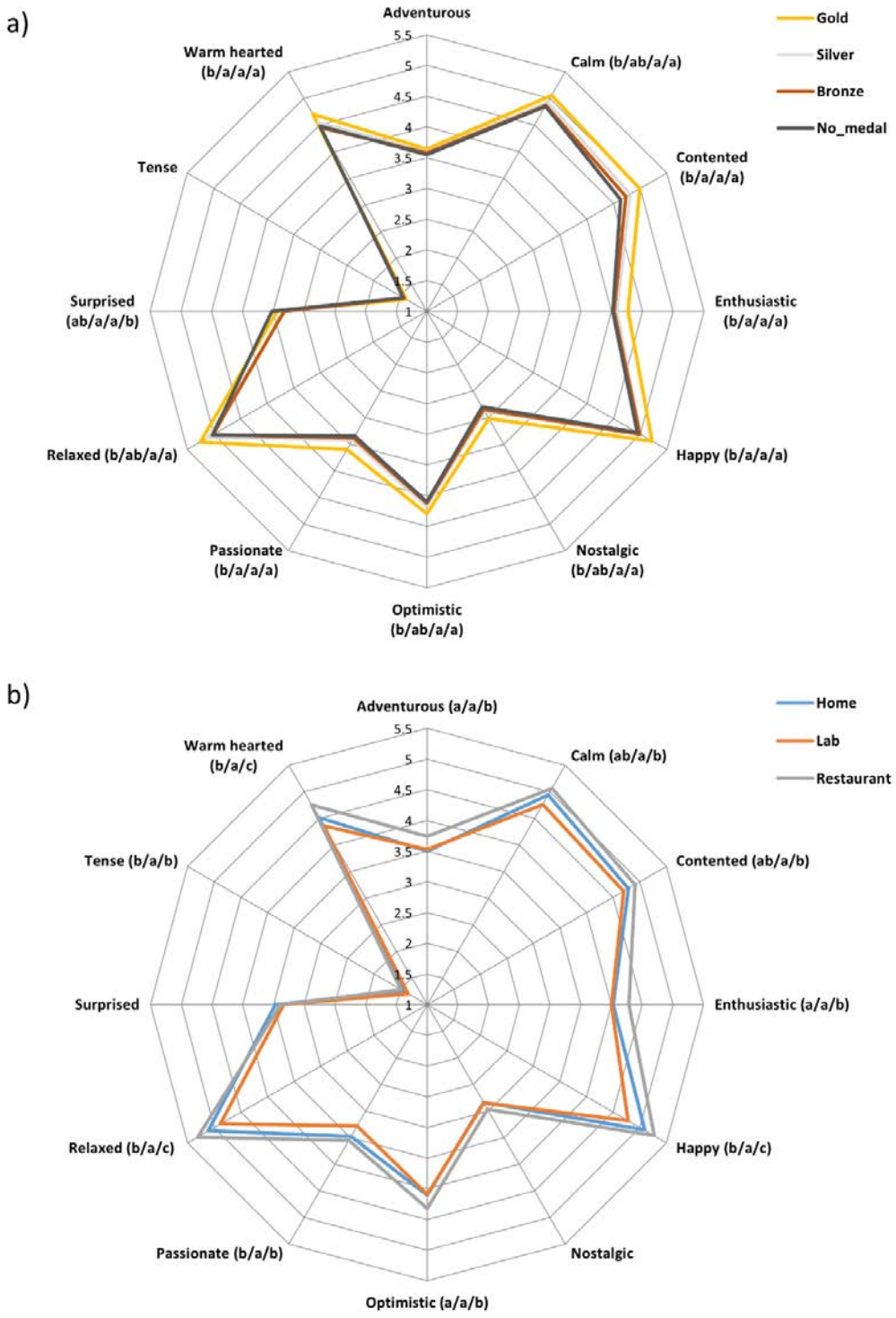


Figure 10: Emotion profiles of a) the four wine quality levels (pooled for the 3 contexts); and b) of the three contexts (pooled for the four quality levels). Intensity of the emotions perceived were measured on a 9-point scale, ranging from 1 = not at all to 9. Only emotion terms that discriminate between wine quality level or context ($p < .05$) are presented. The results of the Bonferroni corrected post hoc comparisons are presented as letters (left to right = order of legend; means with different letters are significantly different at $p < .05$). Reprinted from Food Research International, Vol. 89, Danner et. al., Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines, 254–265, Copyright (2016), with permission from Elsevier.

Investigating consumers moods in the 3 different consumption situations, significant effects on consumers' moods before tasting the wines were observed for *energetic*, *anxious*, *happy* and *loving*, indicating that participants felt happier and more *loving* in the restaurant and home setting, compared to the laboratory setting (Table 7). The opposite effect can be observed for *fearful/anxious*, which showed that participants felt slightly more *anxious* in the laboratory setting.

Table 7: Wine consumers moods in the 3 consumptions situations. Adapted from Danner et al. 2016.

	Home			Lab			Restaurant		
Moods	Mean	SE	sig. diff.	Mean	SE	sig. diff.	Mean	SE	sig. diff.
Angry	1.266	.042	ns	1.248	.041	ns	1.205	.036	ns
Calm	6.175	.091	ns	6.193	.090	ns	6.288	.084	ns
Energetic	4.882	.100	**a**	5.084	.102	**ab**	5.165	.096	**b**
Fearful/ Anxious	1.585	.062	**a**	1.952	.075	**c**	1.758	.069	**b**
Happy	6.268	.074	**b**	6.080	.077	**a**	6.536	.071	**c**
Loving	5.602	.098	**b**	5.197	.103	**a**	5.544	.099	**b**
Sad	1.361	.046	ns	1.430	.051	ns	1.378	.054	ns
Tired	3.464	.101	ns	3.443	.097	ns	3.412	.103	ns

Results were obtained by a Mixed-model ANOVA, mean values, SE and Bonferroni corrected post-hoc comparisons.
Mean values for contexts within a given mood (row) not sharing the same letter are significantly different at $p < 0.05$.

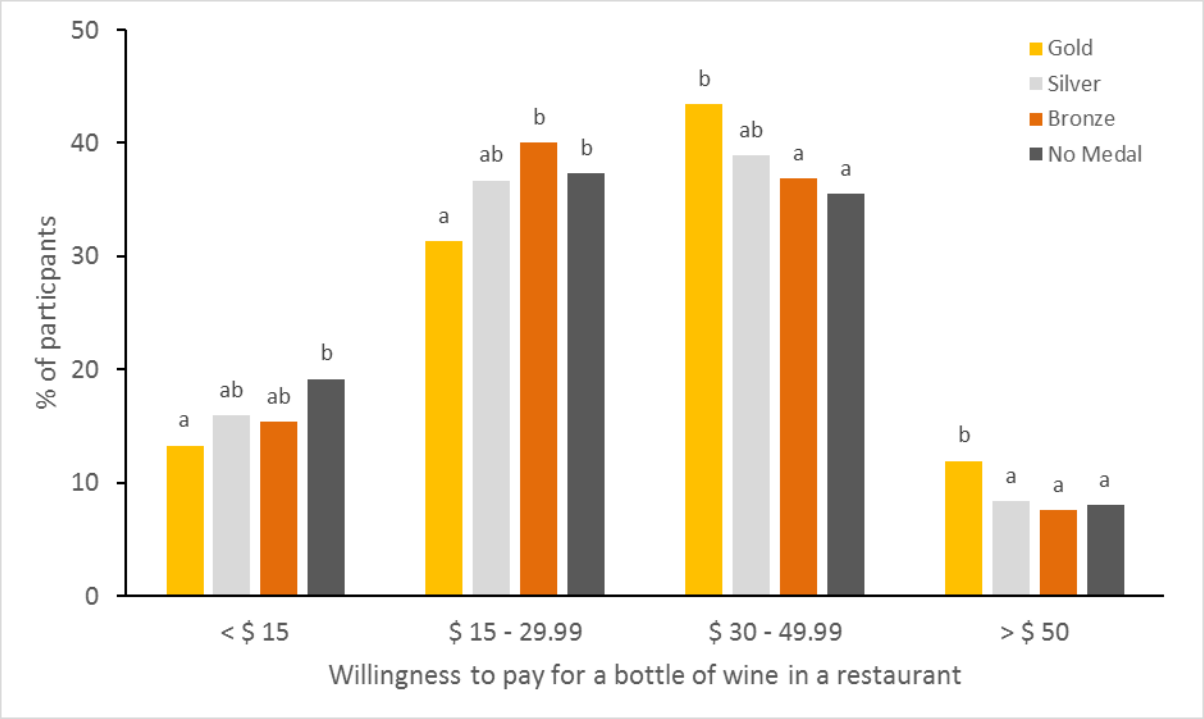


Figure 11: Willingness to pay (maximum price a consumer is willing to pay) for one bottle of wine in a restaurant pooled for the three contexts. Different letters indicate significant differences, based on the performed z-test ($p < .05$). Reprinted from Food Research International, 89, Danner et. al., Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines, 254–265, Copyright (2017), with permission from Elsevier.

Furthermore, a significant relationship between willingness to pay and wine-evoked emotions was observed (Figure 12). If a wine was able to evoke more intense positive emotions (e.g., *nostalgic, enthusiastic and happy*) participants were willing to spend substantially more for this wine. The opposite was true for negative emotions, even if a wine evoked negative emotions (such as *irritated* or *unfulfilled*) to a very weak extent, participants were not willing to spend much on the wine. In agreement with previous findings (Bhumiratana et al., 2014; He, Boesveldt, de Graaf, & de Wijk, 2016; Ng et al., 2013; Spinelli et al., 2014, 2015; van Zyl & Meiselman, 2015), even if negative emotions are generally perceived less intensely and less frequently compared to positive emotions in the food context (Desmet & Schifferstein, 2008), they can deliver important additional information.

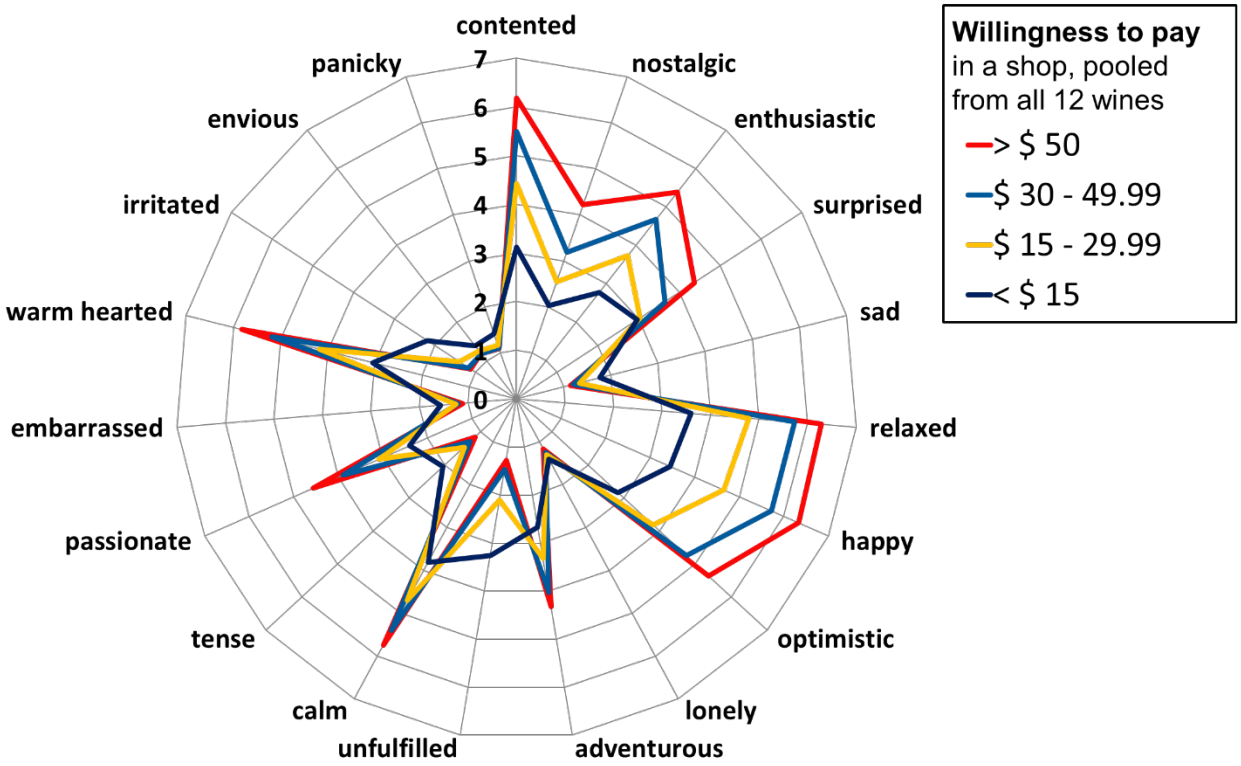


Figure 12: Relationship between willingness to pay and product-evoked emotions (ranging from 1 – "not at all" to 9 – "extremely") for all twelve wines. Adapted from Food Research International, 89, Danner et. al., Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines, 254–265, Copyright (2017), with permission from Elsevier.

In conclusion, this study showed:

- that overall consumers preferred high quality wines (higher liking rating, more intense positive emotions, higher willingness to pay). However, consumers' perception did not fully align with expert quality perception especially for the discrimination between silver, bronze and no medal wines.
- context effects were found on wine-evoked emotions but not on liking, indicating that although emotions and liking are correlated, the measurement of emotions can deliver additional information over liking,
- consumer wine tasting trials performed in a sensory laboratory may produce comparable results to the trials conducted at home or in a restaurant setting.

6.2.2. How wine description information influences consumers expectations and perception of Australian white wines

A manuscript base on this study has been published in Food Research International: Danner, L., Johnson, T. E., Ristic, R., Meiselman, H. L., & Bastian, S. E. P. (2017). "I like the sound of that!" Wine descriptions influence consumers' expectations, liking, emotions and willingness to pay for Australian white wines. 99, 263–274.

The importance of wine labels and label information has been widely studied (Barber, Almanza, & Donovan, 2006; Barber, Ismail, & Taylor, 2007; Chaney, 2000; Kelly & Hyde, 2015; Mueller, Lockshin, Saltman, & Blanford, 2010; Sherman & Tuten, 2011; Tang, Tchetchik, & Cohen, 2015; Thomas & Pickering, 2005), showing that they can play an important role for consumer choice. However, studies investigating the interplay of information presented describing the wine and intrinsic product characteristics in combination with preference tasting are very limited.

This study aimed to investigate how different information levels: blind tasting; basic and elaborate wine description information; influence consumers' liking, emotional response profiles and willingness to pay for commercial Australian white wines. Three commercially available white wines (mono-varietal Chardonnay, Riesling, Sauvignon Blanc) were evaluated by 126 regular white wine consumers under three information levels; session 1, blind (no information provided); session 2 at least 1 week later, basic (sensory description of the wines) plus elaborate (sensory plus high wine quality and favourable winery information).

The statistical analysis using Repeated Measures ANOVA showed highly significant sample and information effects on consumers' liking and wine-evoked emotions (Figure 13 and Figure 14). Consumers liked the Riesling and Sauvignon Blanc more than the Chardonnay, in all 3 of the information condition. No significant differences were observed between the Riesling and Sauvignon Blanc sample. Presenting the wines with basic sensory information significantly increased consumers' liking and positive emotion responses compared to blind tasting. More elaborate wine descriptions which were more emotional, included positive wine quality and winery background information resulted in even more positive consumer responses (higher liking ratings, more intense positive emotions) compared to blind and basic information condition.

At an individual level, it was found that if expectations caused by the wine descriptions were not met by the intrinsic characteristics the positive effects of information decreased or even resulted in a more negative perception of the wine. This can also be seen with the Chardonnay sample which was significantly liked more together with the elaborate information but did not reach the level of Riesling or Sauvignon Blanc with the same level of information.

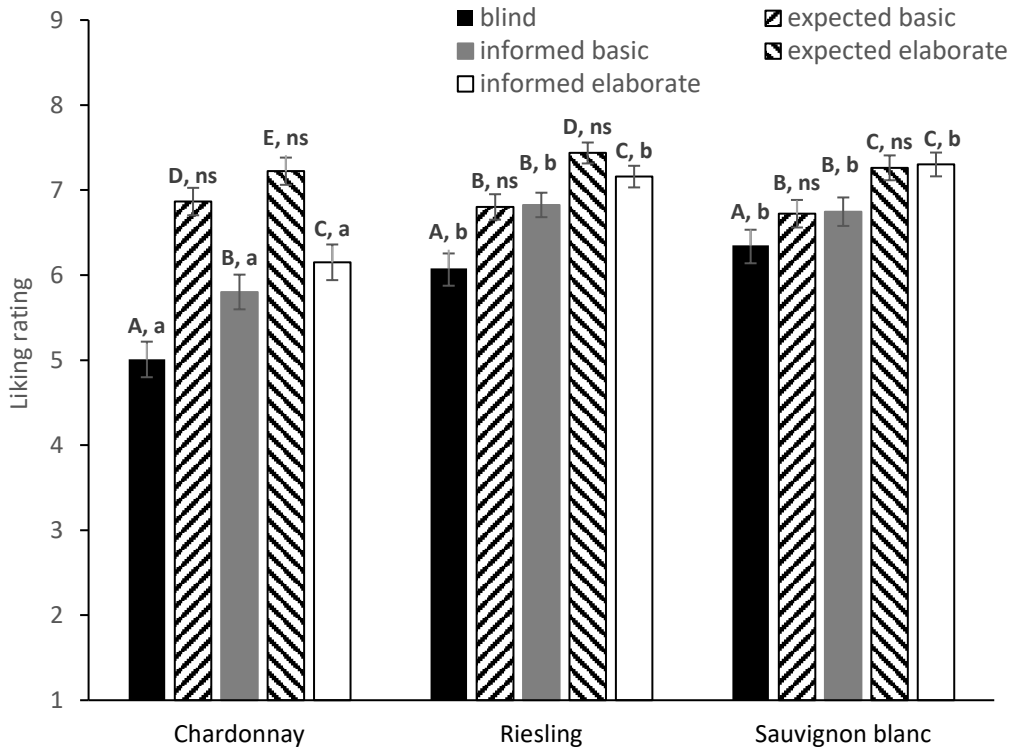


Figure 13: Mean expected liking and informed liking ratings for the three wines in the information levels; blind tasting, basic and elaborate information level (n = 126; 1 = dislike extremely to 9 = like extremely). Capital letters indicate significant differences in liking ratings within one wine variety based on post-hoc comparisons using Fisher's LSD $p < 0.05$. Lower case letters indicate significant differences in liking ratings across wine variety based on post-hoc comparisons using Fisher's LSD $p < 0.05$. Error bars indicate standard error. Reprinted from Food Research International, Danner et al., "I like the sound of that!" Wine descriptions influence consumers' expectations, liking, emotions and willingness to pay for Australian white wines, Copyright (2017), with permission from Elsevier.

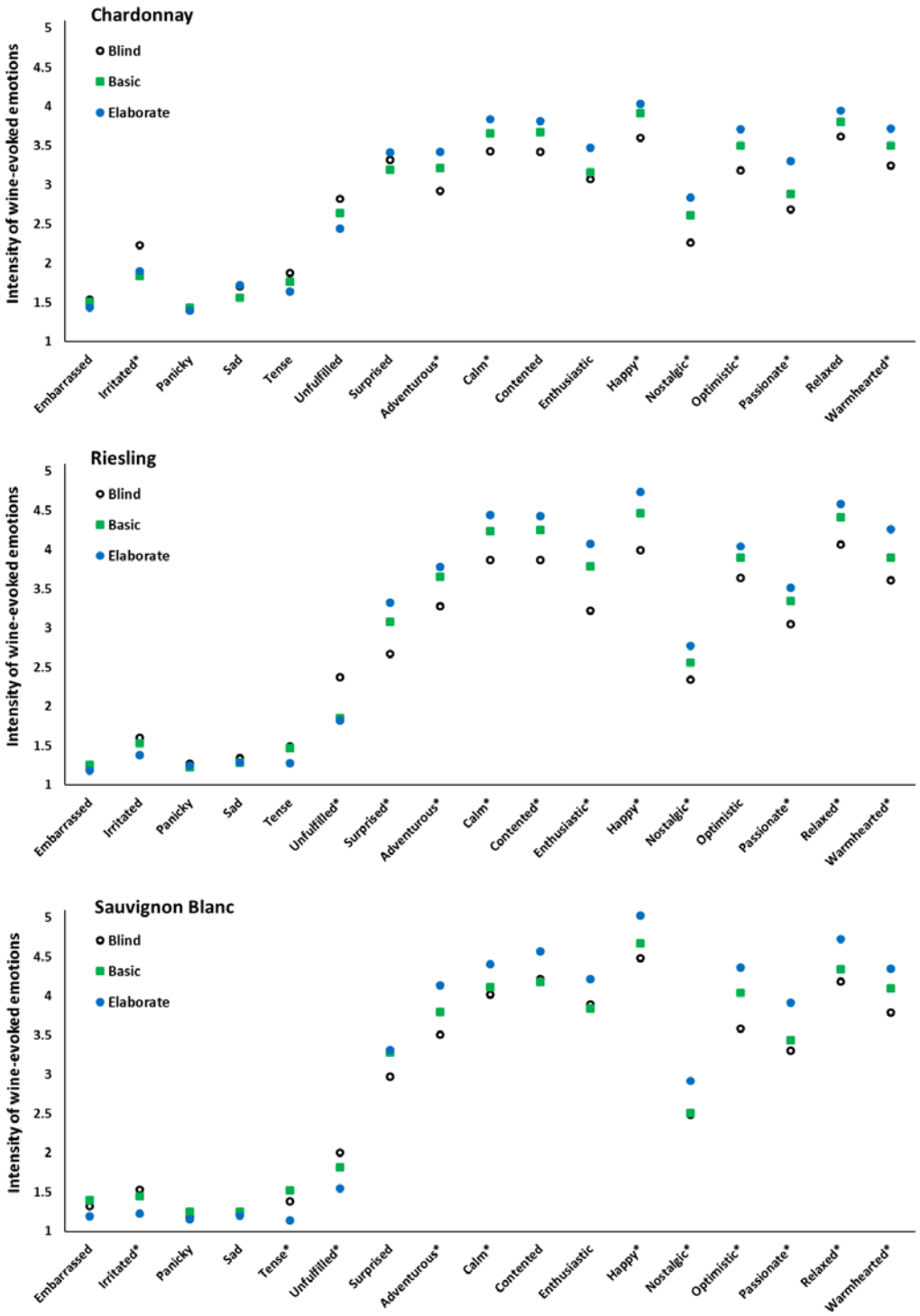


Figure 14: Wine-evoked emotion profiles for a) Chardonnay, b) Riesling and c) Sauvignon Blanc for the three different information levels blind, basic and elaborate description. Intensities of the perceived emotions were measured on a 9-point scale, ranging from 1 = not at all to 9 = extremely. Only emotion terms which discriminate between wine style and/or information ($p < 0.05$) condition are presented. *indicates significant differences between information level within one wine variety ($p < 0.05$). Reprinted from Food Research International, Danner et al., "I like the sound of that!" Wine descriptions influence consumers' expectations, liking, emotions and willingness to pay for Australian white wines, Copyright (2017), with permission from Elsevier.

Furthermore, information condition significantly influenced consumers' familiarity with the wine, willingness to pay for a bottle of wine in a shop and wine quality rating of the tasted wine Figure 15. All 3 increased from blind tasting to the elaborate tasting conditions, with the basic descriptions ranging in between, showing that consumers were more familiar with the tasted wine, were willing to pay more for the bottle of wine and also perceived the wine of being of higher quality when presented together with the elaborate descriptions. It is also worth noting that the increase in willingness to pay for a bottle of wine in a shop was quite substantial, increasing by 21% for the Sauvignon Blanc, 29% for the Riesling and 37% for the Chardonnay sample from blind to elaborate tasting condition.

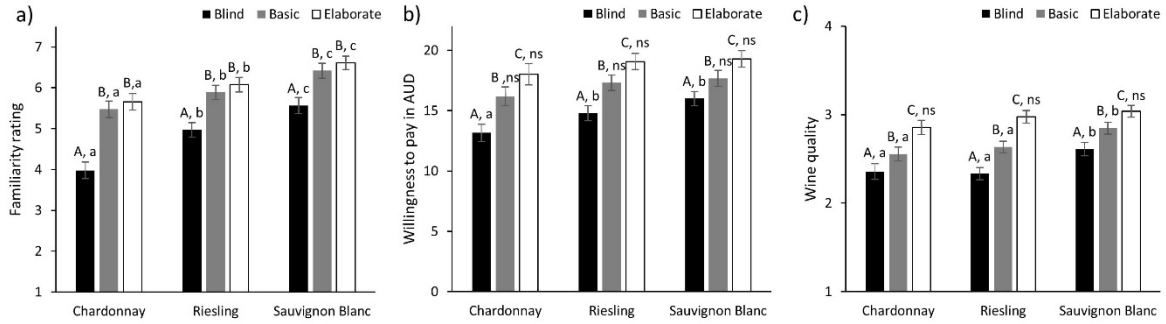


Figure 15: Effect of information level (blind, basic and elaborate) on a) familiarity, b) willingness to pay for a bottle of wine in a bottle shop in AUD and c) wine quality ratings. Familiarity was rated on a 9-point scale ranging from 1-not familiar to 9-very familiar. Wine quality was rated on a 4-point scale from 1-low quality to 4-high quality. Capital letters indicate significant differences in ratings within one wine variety, lower case letters indicate significant differences in liking ratings across wine variety based on post-hoc comparisons using Fisher's LSD $p < 0.05$. Error bars indicate standard error. Reprinted from Food Research International, Danner et al., "I like the sound of that!" Wine descriptions influence consumers' expectations, liking, emotions and willingness to pay for Australian white wines, Copyright (2017), with permission from Elsevier.

In conclusion, this study showed:

- that wine description information presented together with wine can not only change consumers preferences but also changes their whole wine consumption experience including liking, wine-evoked emotions, wine quality perception and willingness to pay,
- although more elaborate information can positively influence consumers perception of the wine, it is important that the consumers' expectations evoked by the descriptions are confirmed by the actual intrinsic characteristics (taste and flavour) of the product,
- involving consumers in the final optimisation stages of the written content describing the wines for labels or online web shops could be beneficial for producers.

6.3. Assessment of which emotional responses are elicited by certain wine flavours and how this influences wine consumers' perception of wine quality, preference and purchase decisions.

A better understanding of how certain flavours influence consumers' perception including hedonic (liking) and emotional responses to wine, may offer the Australian wine industry the potential to develop wines best suited to the consumers' consumption occasion and experiences providing an advantage over competitors.

6.3.1. Wine consumers' hedonic and emotional responses to wine-related aromas for different seasons and contexts: a cross-cultural study

A manuscript base on this study has been submitted for publication to Food Quality and Preference: Ristic, R., Danner, L., Johnson, T.E., Meiselman H.L., Hoek, A.C., Jiranek, V. and Bastian, S.E.P. Wine consumers' hedonic and emotional responses to wine-related aromas for different seasons and contexts: a cross-cultural study.

Studies by others and us have examined wine consumer wine flavour likes and dislikes. It is also well known that consumer preferences can be highly dependent upon the occasion. This clearly indicated the need for the wine industry to not only understand wine flavour, but consider a more personalised, consumer centric approach in producing wines to meet market needs by taking wine consumer consumption occasion into account too. Thus, this component of the project involved the identification of desirable wine characteristics for specific occasions in three of Australia's important target wine markets.

An online survey was conducted with 3000 wine consumers from three different countries, Australia, United Kingdom and USA (1000 participants each), to investigate wine aroma preferences, emotional associations and preferred consumption season and context.

Results showed that out of the 59 investigated white and red wine aromas/flavours, wine consumers liked blackberry, raspberry, strawberry and blueberry most, whereas aromas of gamey/meaty, soy sauce, barnyard and salami were least liked (Figure 16). Overall, there seems to be a high agreement across Australian, UK and American consumers regarding flavour liking. Nevertheless, differences for several aromas were observed. US consumers tend to like aromas of blackcurrant, rockmelon, lychee and musk in wine significantly less compared to

Australian and UK consumers. The opposite effects were observed for strawberry and chocolate.

For 9 wine aromas (chocolate, confectionary, mint, strawberry, passionfruit, pepper, lemon, rose and barnyard) covering a wide range of different aroma groups, the consumers' emotional associations were assessed. Results of the correspondence analysis (CA) showed that the lemon and mint aroma was associated with energetic, chocolate and rose with romantic, and pepper and barnyard with disgusted emotions (Figure 17). In general, the aroma-emotion associations were rather consistent across countries. However, clear differences were observed for confectionary; Australian and UK consumers associated this aroma predominantly with disgusted; in contrast US consumers associated the same aroma more with romantic. Being aware of cultural differences can be beneficial for producers and marketeers to design wine with desired sensory attributes for the intended market.

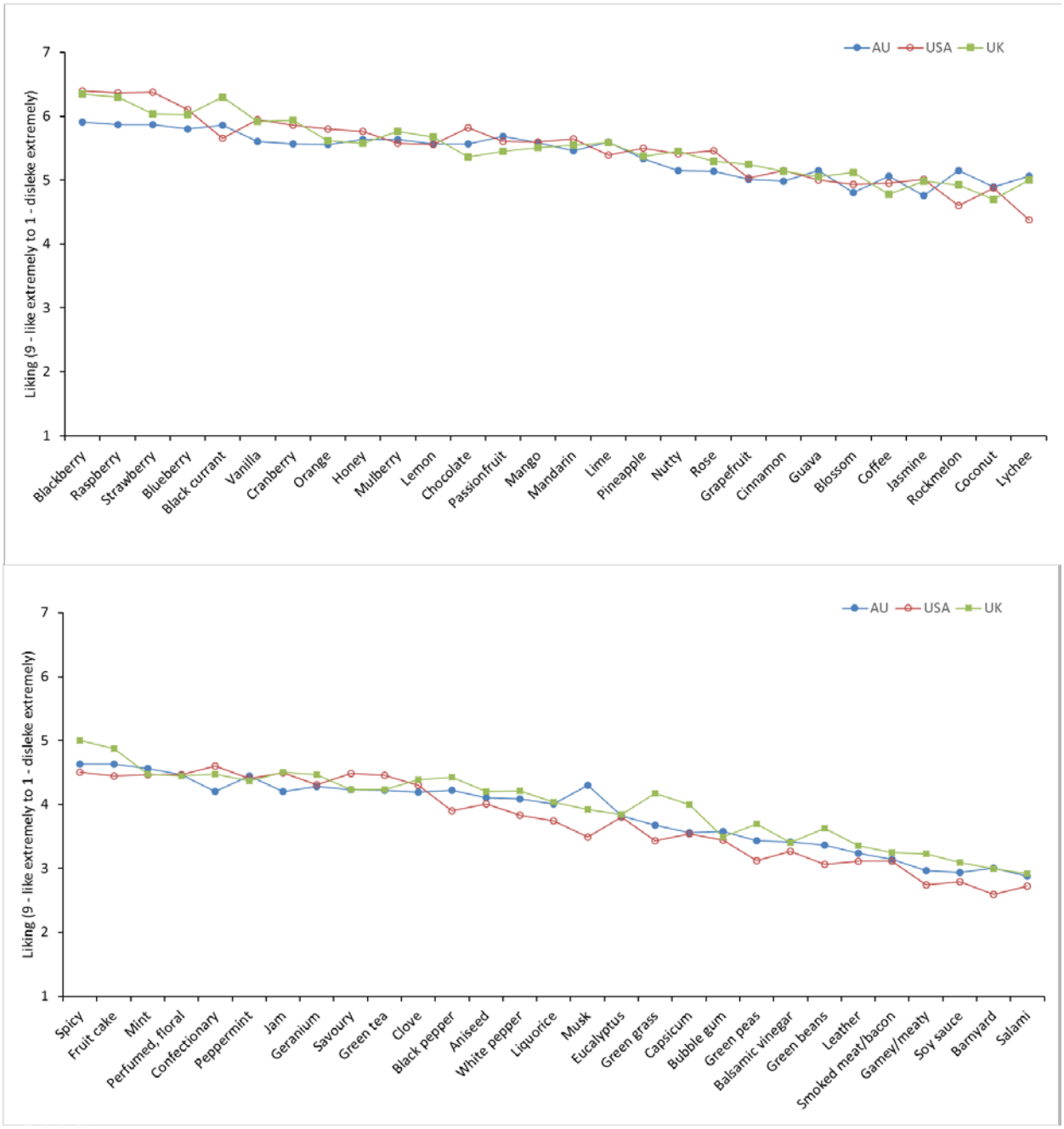


Figure 16: Cross-cultural differences in liking of 59 flavours, rated on a 9-point hedonic scale (9 - like extremely to 1 – dislike extremely.

Upon examination of preferred consumption season, results show that fruity flavours such as lemon, passionfruit and strawberry were preferred in summer and spring; chocolate on the other hand was preferred more in winter and autumn (Figure 18).

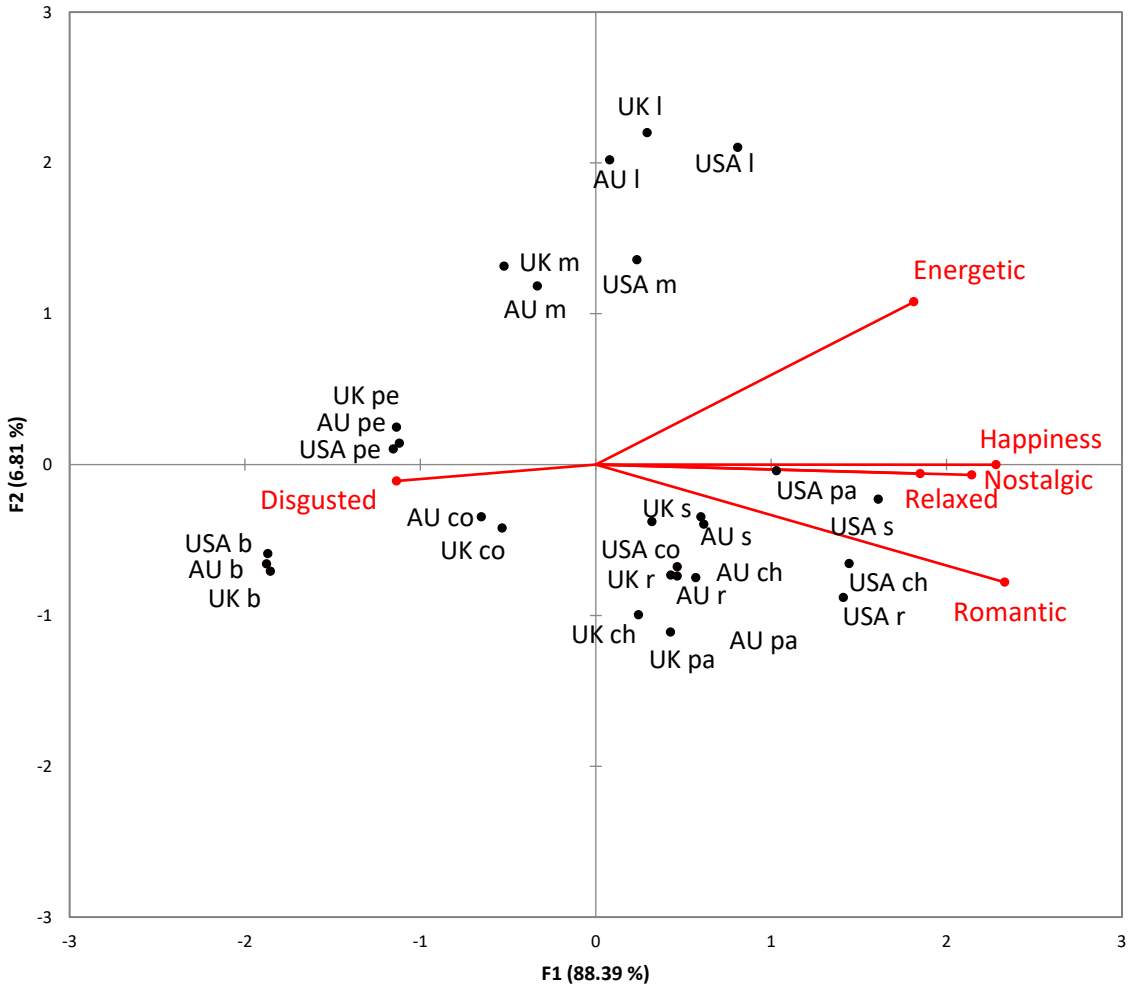


Figure 17: Correspondence Analysis bi-plot of six emotional variables associated with 9 selected wine flavours. The six emotional variables were: happiness– well-being – pleasantly surprised; energetic – invigorated– clean; nostalgic – amusement – mouth-watering; relaxed – serene – reassured; romantic, desire, in love and disgusted – irritated – unpleasantly surprised. Ch=chocolate, l=lemon, s=strawberry, pa=passionfruit, r=rose, m=mint, co=confectionary, b=barnyard and pe=pepper.

Looking at the preferred consumption situation (Figure 19), it was found that rose and chocolate aromas were preferred in a restaurant, while lemon aroma was more associated with consumption at a party or BBQ. Strawberry and passion fruit were liked anywhere, whereas consumers would not like to consume wines with pepper or mint flavour. Probably the most interesting finding is that aromas of similar liking but associated with different emotions i.e. chocolate (romantic) and lemon (energetic) highly differed in preferred consumption season and situations (chocolate, winter/autumn and in restaurant compared to lemon, summer and at parties or BBQ) and that these differences might be explained well by the emotions associated with the aromas. This result clearly shows that investigating emotional responses and

consumption setting in addition to liking ratings can provide valuable information, however future studies need to further investigate the relationship between product-evoked emotions and appropriate consumption setting.

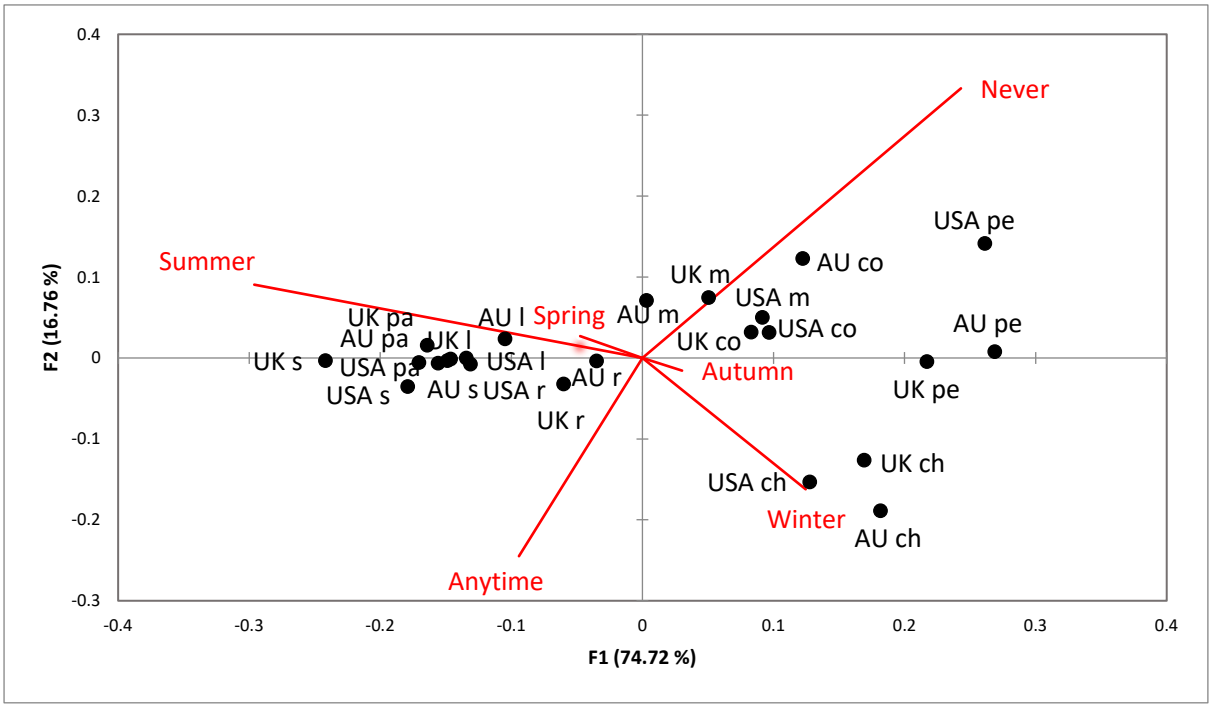


Figure 18: Correspondence Analysis bi-plot showing separation of 9 flavours based on their preferences in different seasons between three countries. Ch=chocolate, l=lemon, s=strawberry, pa=passionfruit, r=rose, m=mint, co=confectionary and pe=pepper.

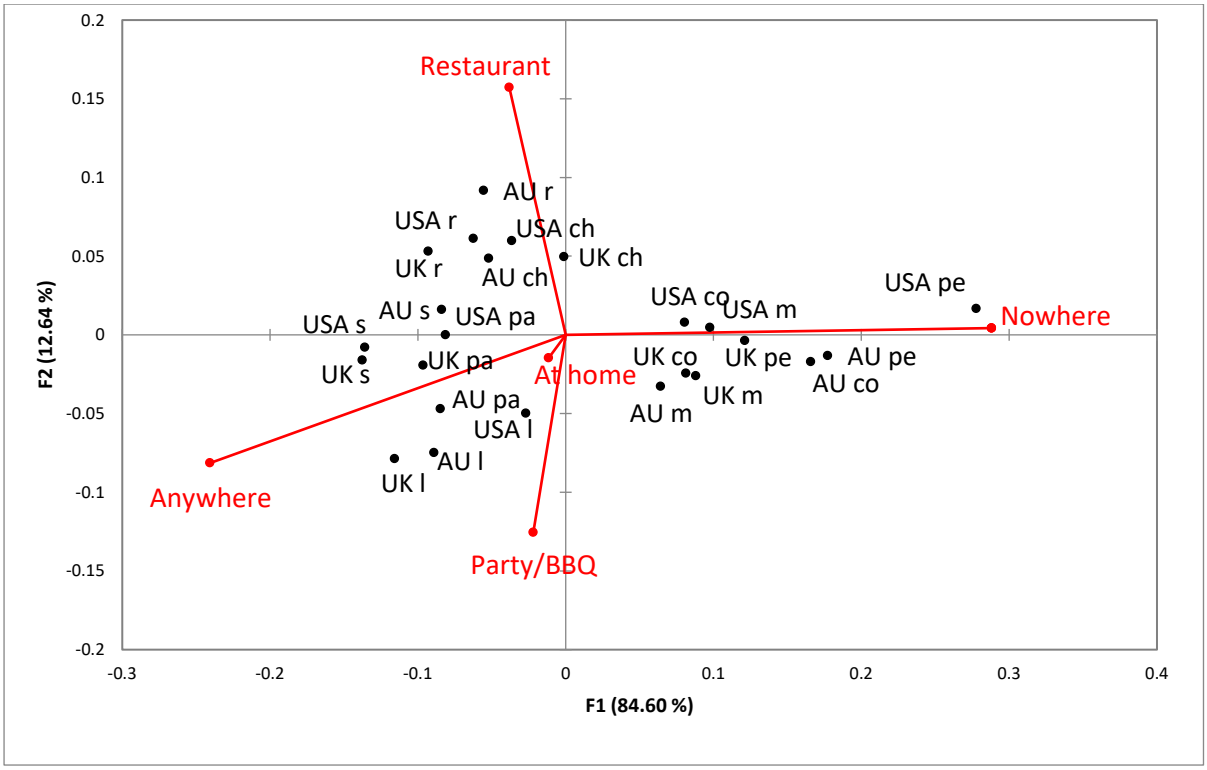


Figure 19: Correspondence Analysis bi-plot showing separation of 9 flavours based on their preferences in different consumption contexts between three countries. Ch=chocolate, l=lemon, s=strawberry, pa=passionfruit, r=rose, m=mint, co=confectionary and pe=pepper.

In conclusion, this study:

- indicates for the first time that wine consumers appear to prefer specific wine flavours for certain occasions
- delivers an overview of consumers' hedonic responses to a wide range of typical wine aromas, providing producers with a starting point to design wines with desired characteristics for specific occasions and seasons for the Australian, UK and US-American market,
- showed that emotional measures in addition to liking can provide valuable information.

6.3.2. Distinct white wine flavours evoke different emotions in consumers

The aims of this study were to examine consumers' preference of wine flavours and to evaluate how distinct flavours influence consumers' perception of white wine including liking and wine-evoked emotions. Gaining a deeper understanding of consumers' preferences and perception of specific wine aromas and flavours can help the industry to produce and market wines targeted to specific consumer segments.

To accomplish this, white wines with distinct flavours characteristics of citrus, fruity, floral, green and oak, but similar in all other characteristics were produced by the addition (spiking) of food grade aroma compounds to a base wine. The selection of the five flavours was based on the consumer survey (section 6.2.1) and spanned from highly to moderately liked aromas. The results of the DA (Figure 20) confirmed that the spikes resulted in the desired flavour characteristics without changing other flavour attributes such as acidity, bitterness or body.

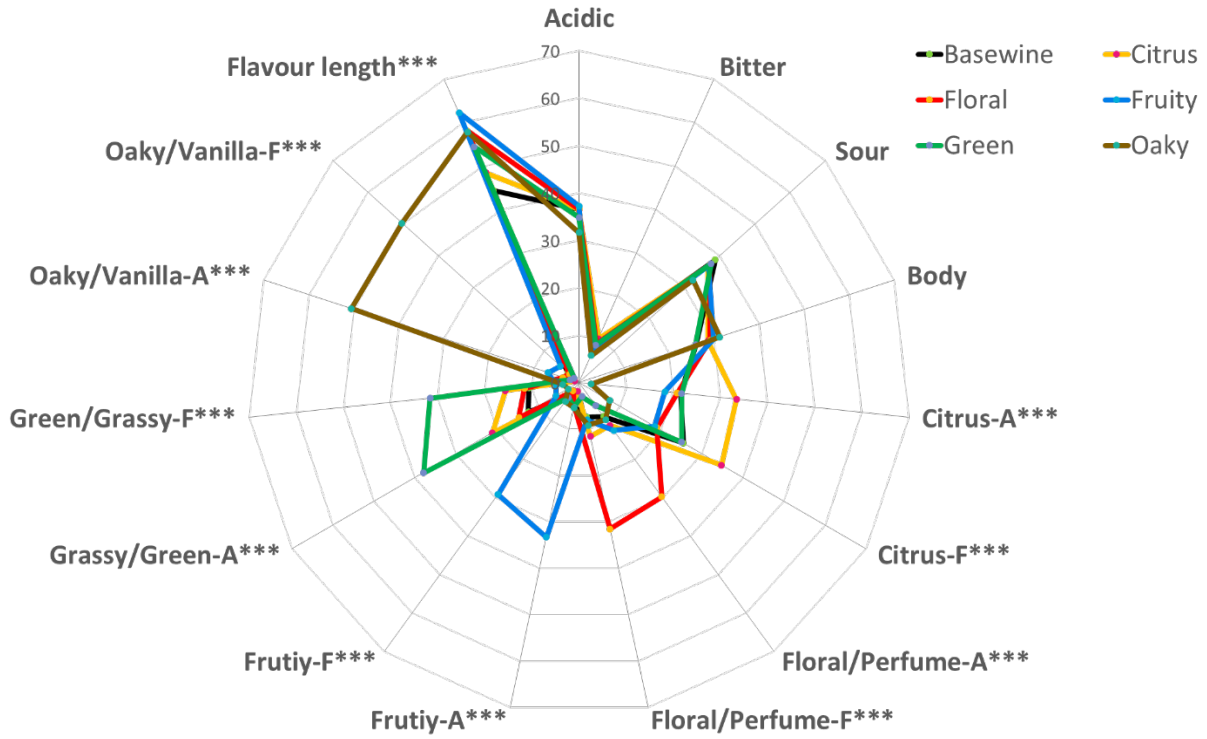


Figure 20: Sensory profiles of the five spiked wines and the base wine samples arising from descriptive analysis (ranging from 1 – "not present at all" to 100 – "very intense"). Significant effects are marked with * p<0.05, ** p<0.01 and ***p<0.001.

Interestingly, the overall results did not fully align with the online survey. Fruity/tropical and green wine samples were liked the most, oaky and floral samples the least, and citrus ranging between those groups for the consumer tasting, whereas in the online survey citrus and oaky flavours were highly liked and green flavours tended to be disliked. This indicates that results of online surveys despite all their advantages require confirmatory consumer tastings.

The hedonic clustering (a cluster analysis performed on consumer liking ratings) identified three distinct clusters. Cluster 1 (wine lovers), participants belonging to this cluster liked all

wines with a preference for citrus, fruity and green wines, but absolutely disliked oak flavour. Cluster 2 (fruity and green likers), disliked oaky, citrus and floral wines but liked fruity, green and the base wine. Cluster 3 (oak lovers), highly liked oak and disliked floral wines. Interestingly, only small differences in terms of consumers' basic demographics were observed across the different clusters (Table 8). Cluster 3, tends to have a slightly higher percentage of male subjects and are slightly more educated compared to the other 2 clusters.

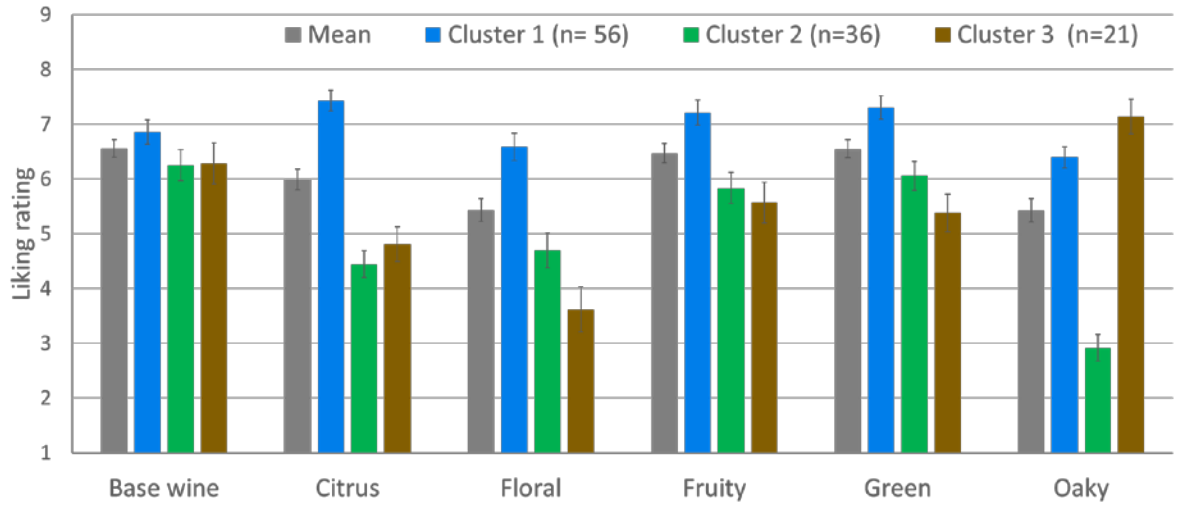


Figure 21: Consumer liking (1 – "dislike extremely" to 9 – "like extremely") for the base wine and five white wines spiked with different flavours.

Table 8: Basic demographic information of the consumer sample and the 3 clusters.

	Total	**Cluster 1**	**Cluster 2**	**Cluster 3**
Gender	n=113	n=56	n=36	n=21
Male	44.2%	41.1%	44.4%	52.4%
Female	55.8%	58.9%	55.6%	47.6%
Age in years				
18-34	20.4%	16.1%	19.4%	33.3%
35-44	15.0%	7.1%	25.0%	19.0%
45-54	17.7%	16.1%	19.4%	19.0%
55-64	22.1%	26.8%	25.0%	4.8%
65+	24.8%	33.9%	11.1%	23.8%
Highest Education				
School Leaving Certificate (15+ years)	4.4%	8.9%	0.0%	0.0%
Year 12 Certificate	5.3%	5.4%	5.6%	4.8%
TAFE Certificate/Diploma/Trade	25.7%	28.6%	25.0%	19.0%
Bachelor's Degree	25.7%	21.4%	27.8%	33.3%
Graduate/Postgraduate Diploma/Certificate	14.2%	16.1%	16.7%	4.8%
Master's Degree	19.5%	16.1%	16.7%	33.3%
Doctorate	5.3%	3.6%	8.3%	4.8%

Significant wine effects on emotions were observed for all three clusters, showing that liked samples evoked more intense positive emotions and the opposite was true for less liked samples, which evoke more intense negative emotions (Figure 22). Cluster 1, perceived most intense positive emotions and very weak negative emotions. In comparison, Cluster 2, perceived, even for liked samples, much significantly weaker positive emotions and especially the oaky sample also evoked considerable negative emotions. The opposite is true for Cluster 3, participants of this cluster perceived most intense positive emotions such as happy, optimistic and relaxed when tasting the oaky samples and felt more intense negative emotions when drinking the floral wine.

In conclusion, this study:

- Identified clusters of consumers with different flavour preferences,
- distinct white wine flavours evoked different emotions in consumers,
- emotional responses are strongly correlated with liking,
- results of the consumer wine tasting did not fully align with the results of the online survey in terms of flavour liking.

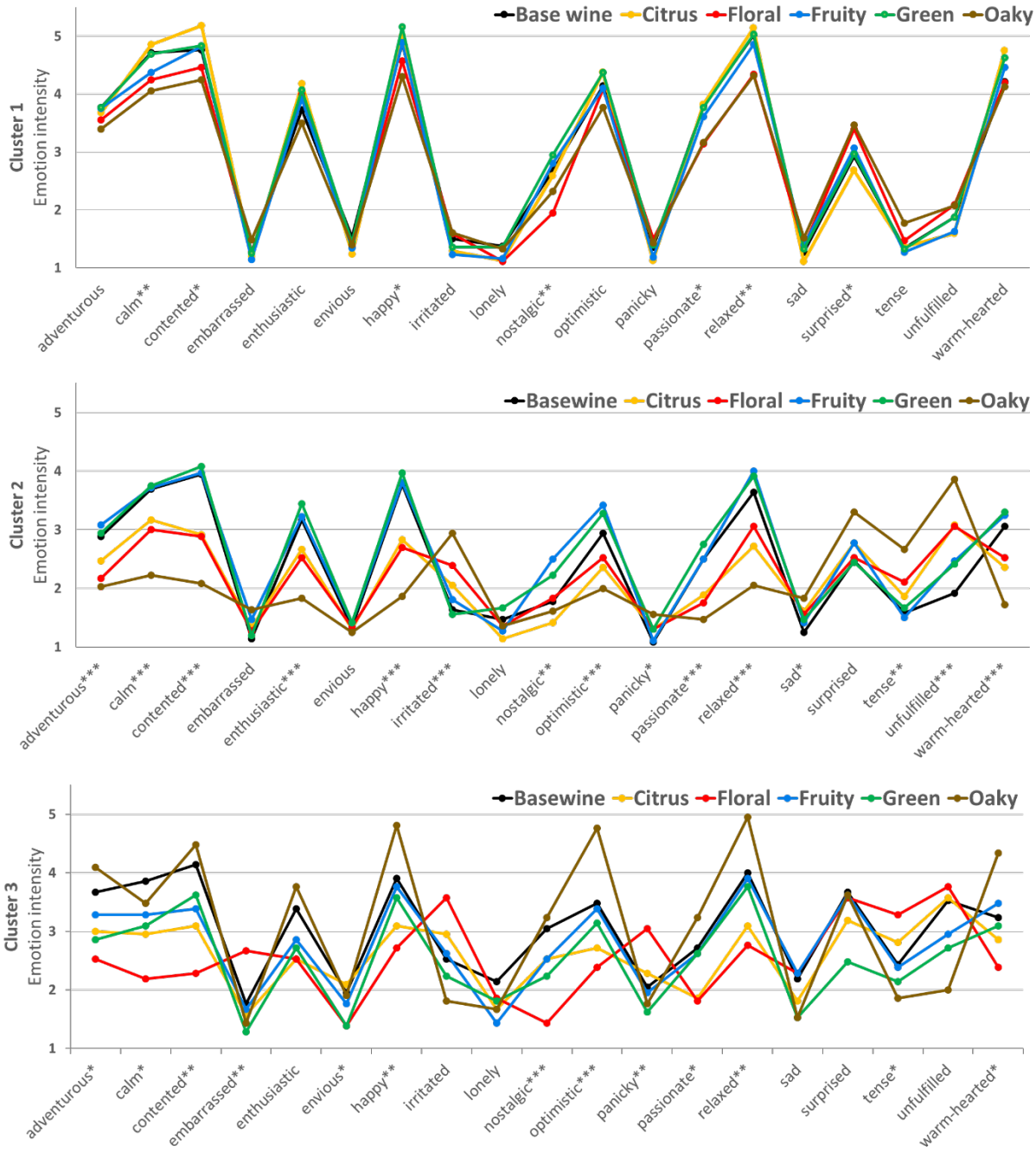


Figure 22: Consumers' wine-evoked emotion ratings (1 – "not at all" to 9 – "extremely") for the three clusters tasting the six wines. Significant effects are marked with * p<0.05, ** p<0.01 and ***p<0.001.

6.3.3. Investigating the influence of selected flavours and consumption context on consumers' liking and evoked emotions for Cabernet Sauvignon

A manuscript base on this study has been published in the American Journal of Enology and Viticulture: Jiang, W., Niimi, J., Ristic, R., & Bastian, S.E.P. (2017). The effects of immersive context and wine flavor on consumer wine flavor perception and elicited emotions. 68, 1-10.

To investigate the influence of wine flavours and consumption situation, a 2 wine flavour (green and floral flavoured) by 2 consumption situations (floral and green pot plant arrangements) design was used.

Results showed that consumers were able to discriminate wine with different flavour characteristics (Figure 23). The control wine (CW) was rated low in floral and green (ranging around 3.5). The Floral wine (FW) was rated significantly higher in floral and less green compared to the control and the green wine (GW). The opposite was found for the green wine, clearly indicating that the consumers could differentiate between the intended flavour characteristics. In this experiment, consumption situation (room decoration) had only a minor influence on the flavour perception (Figure 23). The rating of floral flavour intensity being slightly higher in the floral room compared to the green room.

Examining consumers hedonic responses (Figure 24), it was found that consumers liked the control wine most, closely followed by the floral wine and the green flavoured wine was liked the least ($p<0.05$). No significant interaction between wine flavour and consumption situation on liking was found, indicating that wine flavours were not perceived differently depending on the consumption situation.

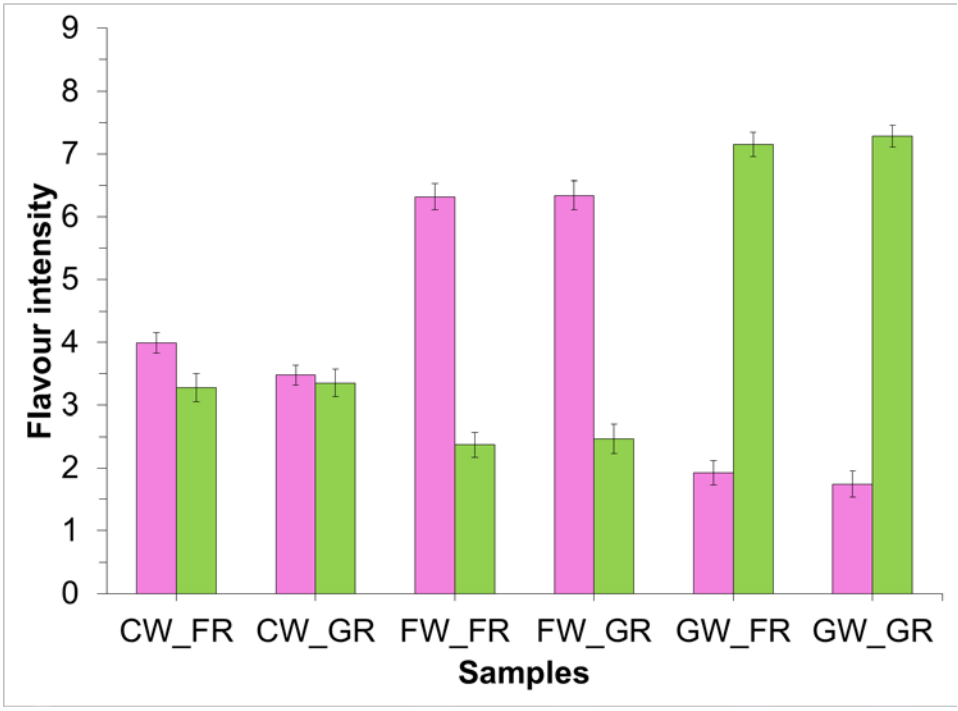


Figure 23: Mean flavour intensities of wines (n=105) in both contexts for floral (pink bars) and green aromas (green bars). Wines: CW=control, FW=floral, GW=green; Rooms: FR=floral and GR=green.

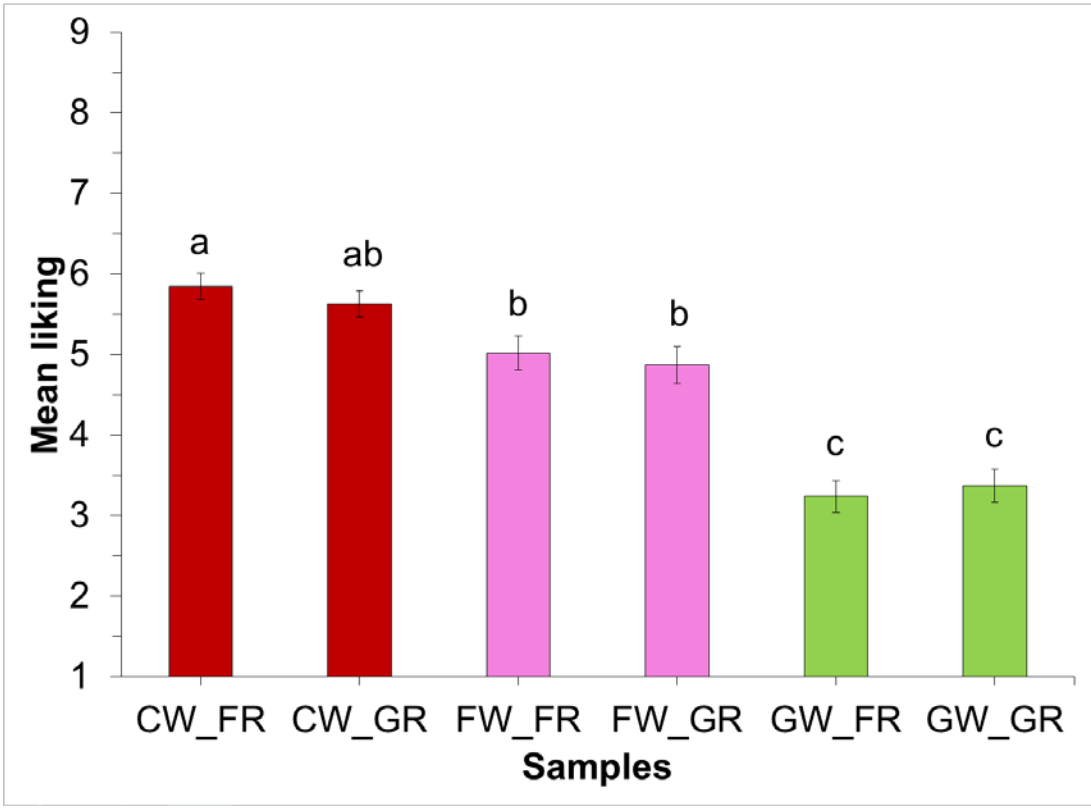


Figure 24: Mean liking of wines (n=105); control (red), floral (pink), and green (green) wines. Rooms: FR=floral and GR=green.

In the next step, consumers were segmented based on their wine liking. Three distinct clusters were identified. Members of cluster 1 liked control wines only. Cluster 2 liked control and floral wines, and cluster 3 liked all wines. Each cluster's emotional profile differed by wine type and heavily depended on liking of the wines (Figure 25). However, differences for similarly liked products were found. No significant difference in liking for the floral wine was found between cluster 2 and cluster 3, however differences in their emotional profiles were observed. Cluster 2 perceived significantly more intense positive emotions (e.g. nostalgic, warm-hearted and passionate) when tasting the floral wine compared to Cluster 3. This indicates that segmentation based on emotional responses could deliver useful information and might be beneficial for targeted product development. Interestingly, consumption situation did not significantly influence consumer's emotion ratings.

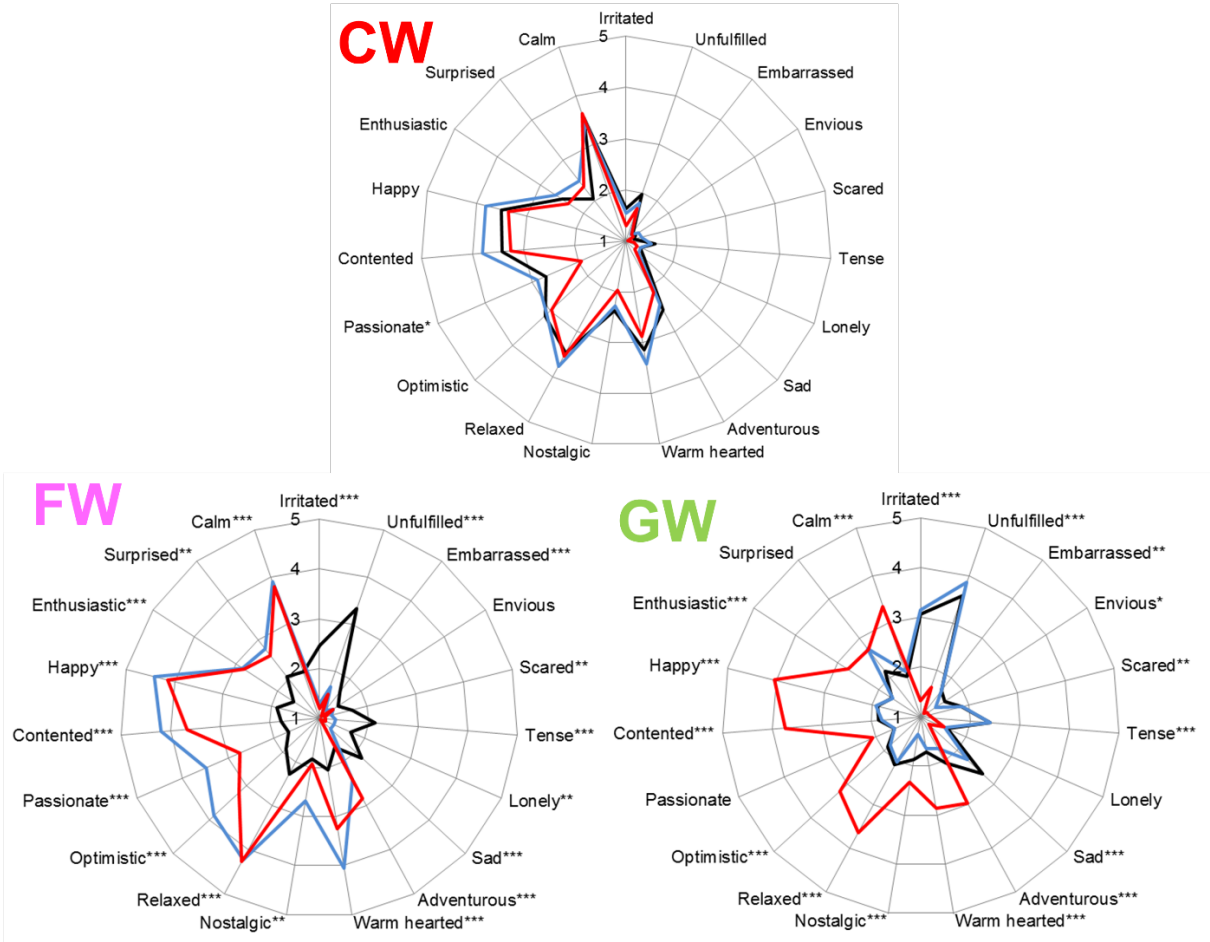


Figure 25: Mean emotion profiles for control wine (top), floral wine (bottom left), and green wine (bottom right). Lines represent consumer segments; cluster 1 (black liked CW only), cluster 2 (blue liked CW & FW), and cluster 3 (red liked all wine). *** = p<0.001, ** = p<0.01, * = p<0.05.

In conclusion, this study showed that:

- emotional profiles for a given wine can be different across clusters despite the clusters having similar hedonic responses to the wine, indicating that consumer groups react differently to specific wine flavours.
- the potential applications of these findings are that this information could be very useful in the marketing of a wine with specific sensory characteristics to a targeted consumer cohort.

6.3.4. Consumer understanding and perception of wine mouthfeel and elicitation of emotions

A manuscript base on this study has been published in Food Research International: Niimi, J., Danner, L., Li, L., Bossan, H., & Bastian, S. E. P. (2017). Wine consumers' subjective responses to wine mouthfeel and understanding of wine body. 99, 115–122.

Wine mouthfeel is a touch sensation that occurs in the oral cavity during wine consumption and is a major contributor to the sensory perception of wine, aside from aromas and tastes, and drives wine quality and acceptance (Bastian, Collins, & Johnson, 2010; Gawel et al., 2000; Pickering & Demiglio, 2008). The current project intended to gain deeper insights into consumers' comprehension and perception of the mouthfeel sensations of astringency and wine body by means of consumer wine tastings and an online consumer survey.

Consumer tasting

The statistical analysis using ANOVA showed that the addition of grape seed extract (GSE) significantly ($p<0.001$) decreased the liking of wines (Figure 26). This result is in agreement with Bastian et al. (2010) who found that consumers prefer less astringent wines. However, in the same experiment, the addition of gum to increase wine body and viscosity, overall had no influence on consumers' wine liking. This finding was surprising as the concentration of added gum was well above the level at which 30 experts could perceive a significant increase in wine body. Thus, it is not clear whether consumers could perceive a difference and it did not affect their liking or alternatively they did not notice a difference in body. Although there are indications of links between consumer wine liking and viscosity of dry white wines (Francis et al., 2010), we could not confirm this with our experiment and additional studies using well controlled viscosity and body levels need to be conducted to further elaborate this relationship.

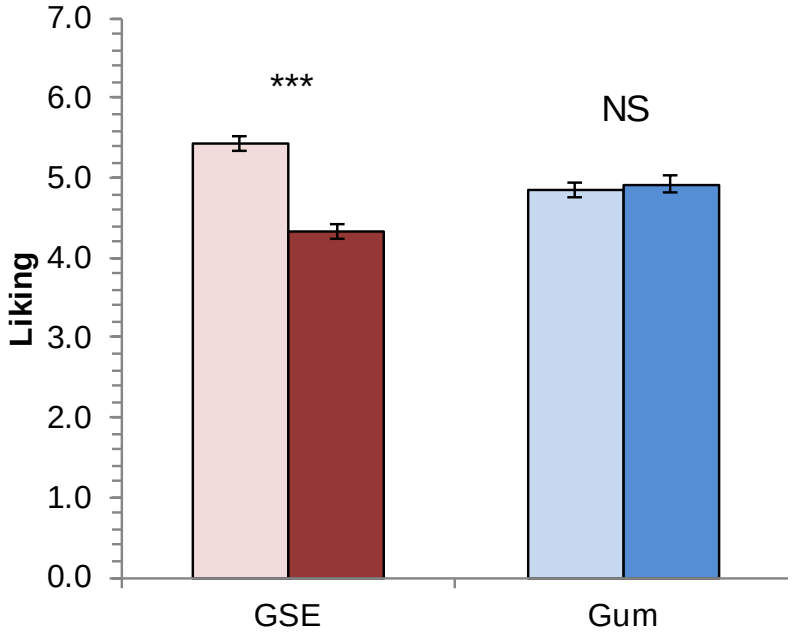


Figure 26: Mean (± S.E.) liking ratings (n=112) by factors of GSE (light red – 0 GSE, dark red – 2g/L GSE), Gum (light blue – 0g/L, dark blue – 0.5g/L gum), *** = p<0.001

Investigation of the differences in emotions elicited by the 2 mouthfeel agents, indicated that the addition of gum, similar to the liking ratings, did not change consumers' emotional responses whereas GSE significantly changed the intensity of 14 wine-evoked emotions. Increased astringency resulted in a clear reduction of the intensity of positive emotions e.g. "happy", "optimistic", "passionate" and an increase in negative emotions e.g. "irritated", "tense" and "sad" (Figure 27). At the current state, there is very little evidence of the direct influence of body on wine preference and emotions felt during wine consumption and knowledge of consumers' understanding of wine body is still lacking.

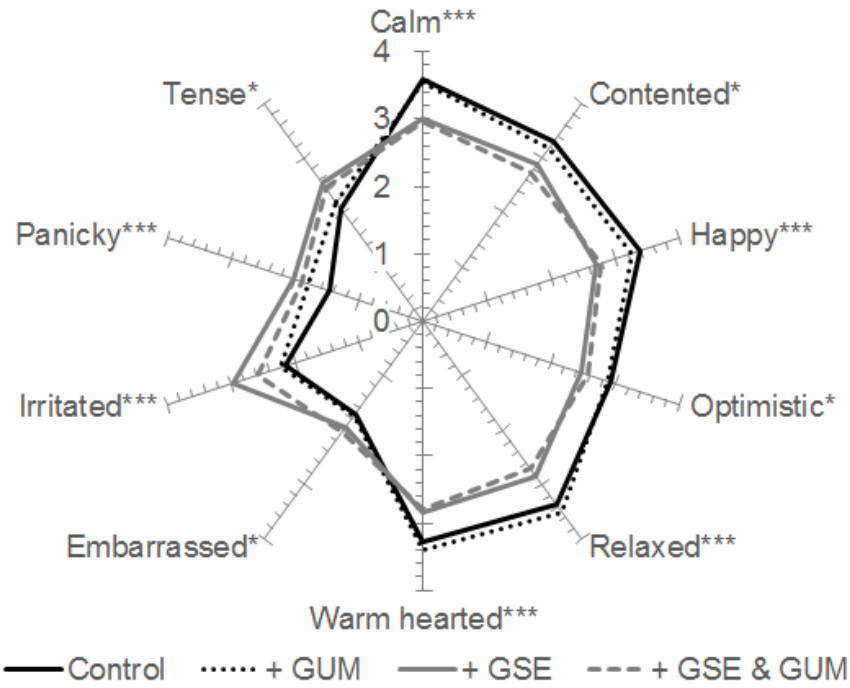


Figure 27: Means of significantly different emotion intensities (n=112) for control (solid black line), wine with gum (broken black line), wine with GSE (solid grey line), and wine with both gum and GSE (broken grey line). *** = p<0.001, ** = p<0.01, and * = p<0.05. Reprinted from Food Research International, Niimi et al., Wine consumers' subjective responses to wine mouthfeel and understanding of wine body, Copyright (2017), with permission from Elsevier.

Consumer survey

The lack of effect of gum added to wine on liking and emotions may stem from how consumers understood wine body, therefore a consumer survey was conducted to investigate how regular wine consumers understand the term of wine body.

Analysing the consumer responses "wine body" was found to be ranked as the third most important wine descriptor on a wine label, behind "wine flavour" and "balance of flavours", for consumers when choosing a wine (Figure 28). Furthermore, 49 % of the consumers indicated that they regularly use the word wine body to describe wines.

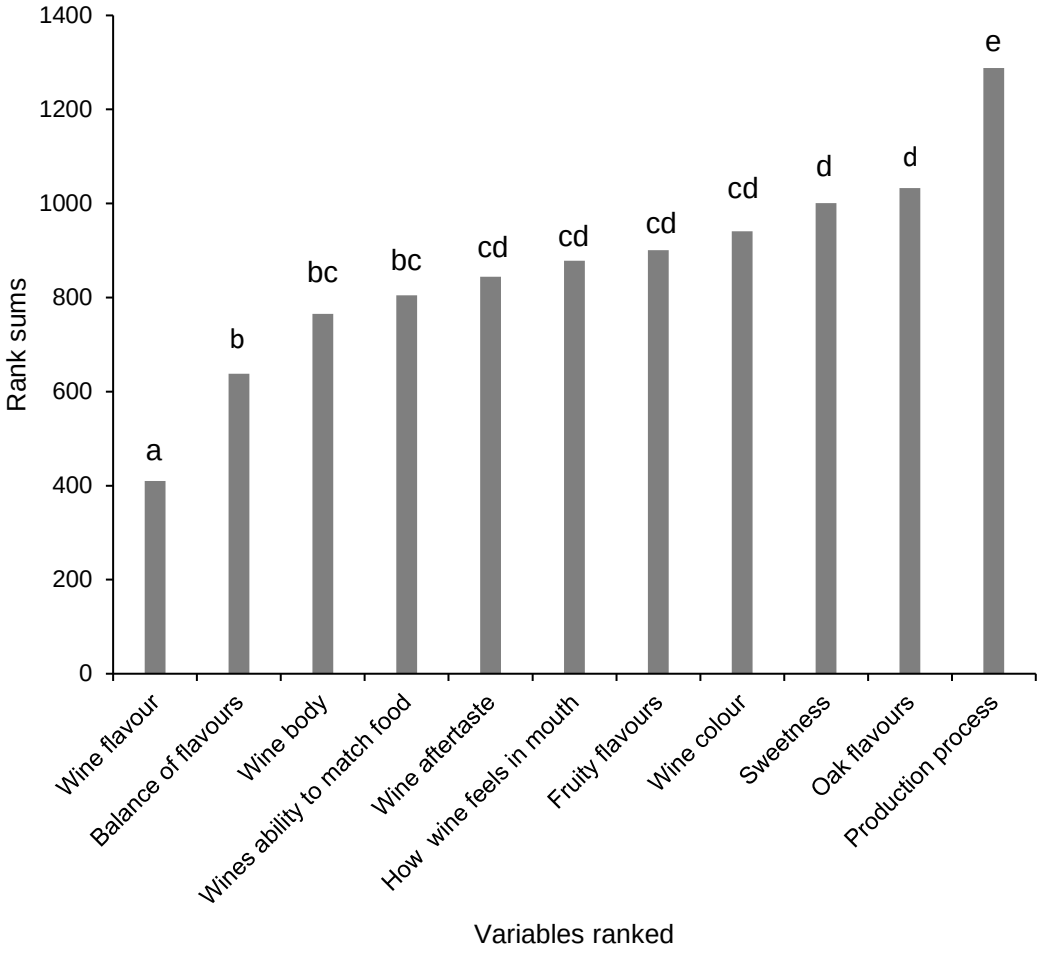


Figure 28: Rank sums (n=136) of the importance to consumers of concepts in relation to wine purchase. Rank sums that share the same superscript are not significantly different according to Friedman's test. Reprinted from Food Research International, Niimi et al., Wine consumers' subjective responses to wine mouthfeel and understanding of wine body, Copyright (2017), with permission from Elsevier.

Although the results undoubtedly show that wine body is an important and often used term by consumers, there are clear differences in how consumers define the term body. Over 30 % of the consumers in their own words and unprompted used the term "flavour" to define wine body followed by "fullness", "strength", "taste", "light", and "mouthfeel", all above 15 % of all citations. Especially noteworthy is that although wine body is defined by many experts as a mouthfeel attribute (Jackson, 2009), consumers tend not use mouthfeel and mouthfeel related attributes such as thickness, viscosity and thinness very often. These findings indicate that there is a clear difference between consumers' and experts' understanding of the term wine body and that consumers understand wine body as a more holistic concept including flavour, taste and intensity opposed to a mouthfeel. However, although experts may easily be able to agree on a

given wine's level of body, it is still unclear what constitutes this mouthfeel sensation in wine and further research is required to unravel this enigma.

To investigate how consumers' subjective wine knowledge influences their understanding of wine body, consumers were segmented into 3 groups; less knowledgeable, knowledgeable and highly knowledgeable, using their responses to a subjective knowledge scale (Flynn & Goldsmith, 1999). Highly knowledgeable consumers tended to use texture related terms, such as mouthfeel, thickness and depth more often than less knowledgeable participants (Figure 29). These terms are also typically used by experts to assess wine body (Blake, Kotseridis, Brindle, Inglis, & Pickering, 2010; Gawel, Smith, & Waters, 2016; Nurgel & Pickering, 2005). This suggests that highly knowledgeable consumers have a higher agreement with experts, possibly resulting from their frequent exposure to, learning and reading about wine, leading to a more refined technical articulation of the sensory attributes of wine.

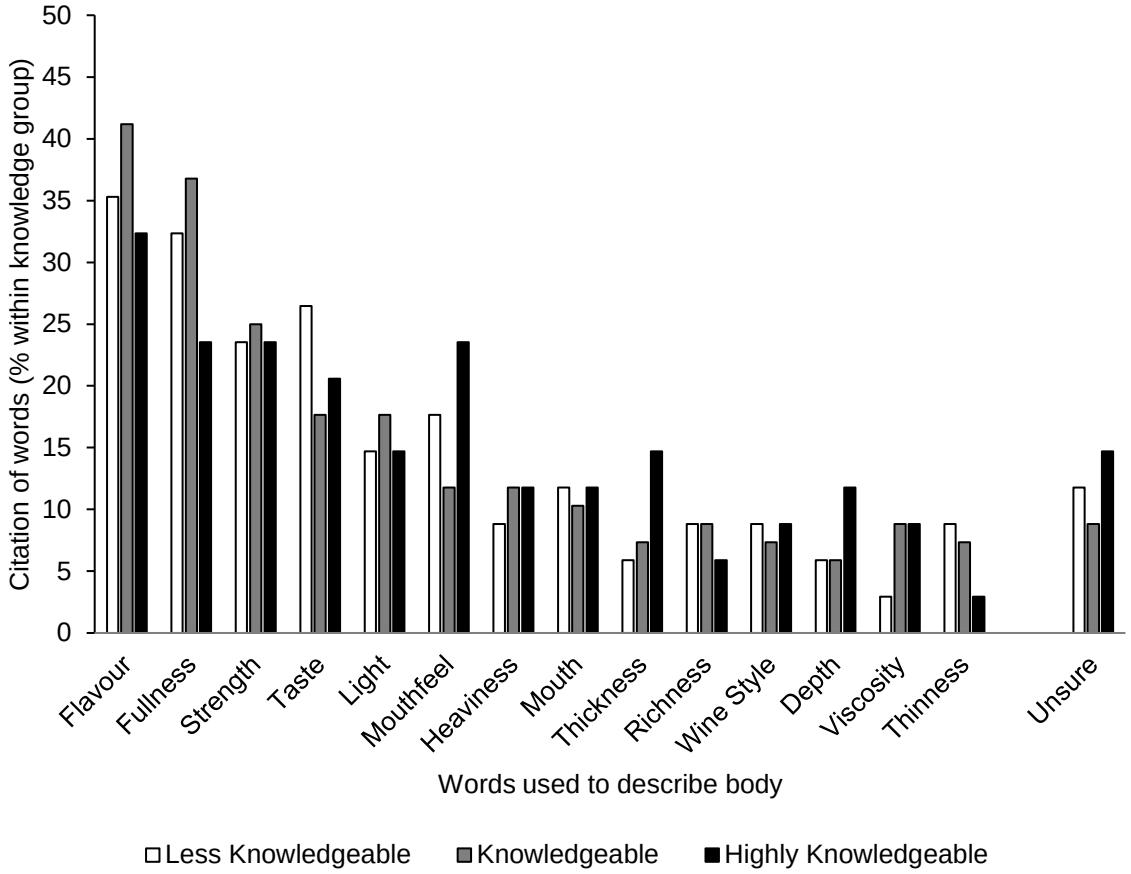


Figure 29: Content analysis of terms important to describe wine body separated by subjective knowledge of wine consumer groups (less knowledgeable n = 34, knowledgeable n = 68, highly knowledgeable n = 34). Reprinted from Food Research International, Niimi et al., Wine consumers' subjective responses to wine mouthfeel and understanding of wine body, Copyright (2017), with permission from Elsevier.

Lastly, consumers were asked which level of body (low, medium, full) they associated with a range of red and white wines commonly consumed in Australia (Figure 30). Wines made from the white varieties Riesling, Sauvignon Blanc and Semillon were mainly associated with low or medium body, whereas the responses to Chardonnay wines were rather mixed. It is not clear if this is due to Chardonnay's being produced in a more diverse range of styles than the other whites e.g. partial/full lees stirring, barrel ferments, oak maturation, malolactic fermentation, reductive characters and fruit forward unwooded styles, or if consumers are just confused or unfamiliar. Either way it needs further research. Most consumers considered wines made from Shiraz and Cabernet Sauvignon as full bodied wines, whereas Grenache, Pinot Noir and Merlot wines were thought to be medium bodied. High consensus was found for Rosé and Sparkling/Champagne which were considered predominantly light bodied, and Tawny/Port which were considered full bodied. Due to the lack of scientific studies classifying wine varieties into body categories, a comparison of the results with literature is not possible. Yet from a wine industry perspective these findings are encouraging, in that consumers on the whole seem to understand the concept in relation to existing wine styles permitting communication with them at some level. It is still likely though that this may be a learned association as opposed to consumers understanding the notion of this mouthfeel sensation per se.

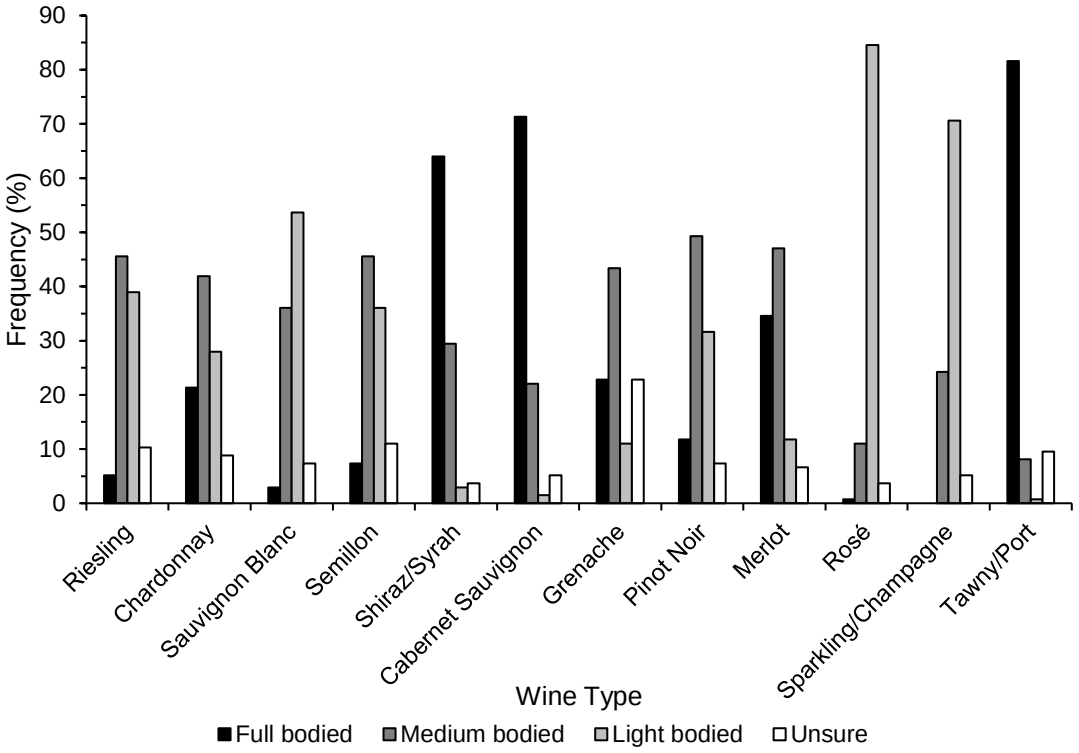


Figure 30: Consumer association of level of body with each type of wine (n=136). Reprinted from Food Research International, Niimi et al., Wine consumers' subjective responses to wine mouthfeel and understanding of wine body, Copyright (2017), with permission from Elsevier.

In summary, this study showed that:

- wine mouthfeel, specifically astringency, can influence consumers' wine liking and perceived emotions.
- although almost 50 % of the consumers frequently use the term body to describe wines, their understanding of the term body appears substantially different to that of experts, in that consumers have more of a holistic flavour percept encompassing the overall magnitude of flavour intensity as opposed to it being purely textural.

Even for experts, wine body can be an ambiguous concept given that what factors drive this sensation still remains largely unclear and no physical measure of body has been found which correlates with perceived body. Regardless, gaining a better understanding of consumers associations and expectations of wine body for a certain wine and indeed their perceptions of other mouthfeel sensations are both important to know and research further. This knowledge should assist the ability of producers and sales personnel to meet their consumers' wine expectations, and as a result, enhance satisfaction of their consumers' consumption experience.

7. Outcome/Conclusion

All three key objectives of this project were achieved.

Objective 1: Investigate the nature of the intrinsic sensory wine drivers behind wine consumers' perception of wine quality within different market segments versus experts' perception of wine quality for wines at different price points.

The relationship between sensory attributes and chemical compounds that drive consumers' liking, emotions, willingness to pay for commercial Shiraz wines and the relationships between consumers' and experts' quality perception of Shiraz wines was assessed. Thus, we now know which Shiraz sensory attributes and chemical compounds are considered important in different quality tiers and that consumers are prepared to pay more for. As we have some knowledge of the chemical pathways that produce these compounds and are continuously gaining a better understanding of the viticultural management and wine production processes that promote them, wine producers can adopt methods to enhance these components in their wines.

A new wine market segmentation method (Wine Neophobia Scale) has been developed to measure wine consumer reluctance to try new wines, so the Australian wine industry can profile and discover who these consumers are and to better understand their needs in future.

Attenuated Total Reflectance Mid-Infrared (ATR-MIR) Spectroscopy of Shiraz wines was not originally proposed, but has been identified as a promising rapid, method to predict phenolic composition of Shiraz wines and Shiraz quality. This could be linked back to attributes in grapes in the vineyard for better objective measures of fruit quality and product allocation.

Consumers liking of mouthfeel characteristics of astringency and wine body has been studied. For the first time, wine flavour and mouthfeel evoked consumer emotional responses have been determined and a detailed understanding of consumer comprehension of wine body gained. This will be useful information to enable better education of consumers and communication about wine mouthfeel.

A new, rapid methodology to measure what consumers smell, taste and feel in wines has been tested and validated, permitting producers to communicate to consumers in a language they understand. The developed method can be the basis of a new digital tool that could be adapted

for and utilised by the wine industry to produce sensory profiles and statistical analysis of their wines negating expensive sensory testing.

Objective 2: Examine the influence of a variety of consumer wine evaluation context effects (mood, occasion, setting, etc.) on consumer wine quality perception and wine preference ratings to define conditions which will ensure the most robust measures of consumer wine preference.

A specific lexicon (AWEEL) was designed to measure Australian wine consumer wine evoked emotions to provide deeper consumer insights over and above traditional wine liking and acceptability data.

A robust validation of how wine consumption context (laboratory, restaurant, home) impacts on consumer liking, emotions and willingness to pay leading to improved consumer testing in future has been performed, indicating that consumer research in controlled environments (e.g. sensory laboratory) can produce valid results relative to real-life situations.

Furthermore, knowledge of how wine description information, such as the wine sensory characteristics of smell, taste and mouthfeel along with wine quality and producer information impacts wine consumer emotions, liking and willingness to pay was gained. This could be incorporated into company wine marketing strategies.

Objective 3: Assess which emotional responses are elicited by certain wine flavours and how this influences wine consumers' perception of wine quality, preference and purchase decisions.

Key wine flavour compounds for the Australian, US and UK markets suited for specific occasions and seasons were identified. Furthermore, the influence of a subsample of these key flavour compounds on consumers wine perception, including liking and wine-evoked emotions was assessed. This information could assist tailoring products more precisely for these markets.

Over the course of the project 2 Masters and 1 Bachelor of Viticulture and Enology students and 8 international interns were trained in wine related sensory and consumer science.

7.1. Project performance against planned output

Although the approach of this project had to be changed slightly due to unforeseeable reasons, all activities of the original proposal (or approved project variations) were successfully completed.

Year 1

Output	Performance
University of Adelaide Post-doctoral research fellow appointed	Postdoctoral fellow appointed
Web-based platform builder engaged	After a tender process Zealed was engaged
Industry reference group formed	Wine Australia responsible to form group
Australian wine consumer data base for platform generated	Recruited and generated a data base of over 1000 wine consumers
Australian wine consumer study on wine aroma and emotion conducted	Completed literature review. Based on identified knowledge gap, the consumer survey was designed and 1000 consumers recruited and undertook survey

Year 2

Output	Performance
Qualitative knowledge of the relationship between wine aroma and consumer emotion	Data collection from 3000 wine consumers in the UK, USA and Australia and analysis completed
Nature-identical flavour compounds to spike wines for second consumer trial on intrinsic aromas and emotions purchased	10 aromas for red and white wines were identified being especially related with consumer liking and quality perception of wines
Final set of commercial wines from different price points for descriptive analysis, wine chemistry and consumer trials purchased	100 Australian Shiraz wines were selected and either donated or purchased for the study Eight wine experts from industry and academia selected 40 wines being most suitable for consumer testing, covering a wide price range and four quality levels
Web-based producer-consumer co-creation platform for a dedicated wine online community launched	12 months was spent by project staff to generate all wire frames (front and back end of the portal). Due to unforeseen, forces affecting the platform provider, a fully functional portal was not made. Novel methods to gather consumer data were developed in its place. A

	publication has been submitted and a digital tool based on this method recommended for future research and industry
Sensory profiles of commercial wine from different price points defined	Data collection and analysis completed
Flavour chemistry profiles of commercial wines completed	Data collection with the addition of MIR and basic chemical analysis of wines and analysis completed

Year 3

Output	**Performance**
Knowledge of environment effects on and intrinsic wine drivers behind wine consumer quality perception, preference and purchase	Wine samples selected and prepared for consumer trials and data collection completed
Understanding of relationships between wine expert quality ratings and consumer quality ratings	Data collection and analysis completed
Manuscript for peer review journals, industry articles and innovator network report submitted	Results presented through various presentations and publications (see Appendix 1 Communications)
Final set of aroma spiked wines selected for consumer trial	Data collection and analysis completed
Quantitative sensory profiles of aroma spiked wines produced	Data collection and analysis completed

Year 4

Output	**Performance**
Flavour chemistry profiles of aroma spiked wines completed	Data collection and analysis completed
Knowledge of interactions between wine aroma, wine consumer emotions and environment	Data collection and analysis completed
Conference presentation at 16th AWTIC	Results presented through various presentations at the 16th AWTIC (see Appendix 1 Communications)

Manuscript on wine aroma/consumer emotion for peer review journals, industry articles and innovator network report and final GWRDC report submitted	Results presented through various presentations and publications (see Appendix 1 Communications) Final report submitted to Wine Australia The researchers are currently working on additional academic publications targeting A level journals

7.2. Benefits from the project

7.2.1. Economic benefits

Australian wine makers produced 1.18 billion litres of wine valued at AUD$4.7 billion in 2015 ("State of Australian Wine: Results of the 2015, Wine Production, Inventory and Domestic Sales Survey.," 2016). The wine industry contributes ~$40 billion annually to the Australian economy and supports ~170,000 jobs, many in regional areas (Gillespie & Clarke, 2015). While continual improvements in quality, consistency and efficiency are required simply to remain competitive in domestic and export wine markets, the Australian wine industry must identify and address the quickly changing consumer preferences and trends by an improved understanding of consumer demands to secure larger market shares and become international market leaders. The methods developed in this project and the gained knowledge will help to understand consumers' needs and preferences in a wide range of real-life occasions, and assist in building the foundation of a more consumer-centric approach for the Australian wine industry. This information and tools are particularly important to understand developing markets such as China, which recently overtook USA as the most important (by value) export market for the Australian wine industry with a year over year growth rate of 51% and value of AUD$ 474 million ("September 2016 Export Report," 2016), to boost sales and drive value into the category.

7.2.2. Environmental benefits

There is no direct environmental impact of this project. The benefits are based on reducing wasted effort and spending on marketing communications to achieve unrealistic or the incorrect goals for positioning Australian wines. Therefore, the environmental impact will be indirectly lowered due to reduced wastage in effort relative to generated value.

7.2.3. Social benefits

This research is not intended to have social impacts, except indirectly. However, economic benefit from this project will lift a national industry that directly employs > 68,000, many in regional areas, and whose premium products underpin the wine tourism industry, which employs a further 105,000 (Gillespie & Clarke, 2015). In addition to jobs, society will benefit from products that result in an enhanced consumption experience and hence better quality to value ratio that adds to our reputation as wine leaders and innovators internationally.

8. Recommendations

A significant finding from this project was the identification of the sensory characters and volatile (flavour) chemical compounds that drive experts' and consumers' quality ratings of Australian Shiraz commercial table wines. The expert panel had indicated complexity and flavour intensity were two of the factors upon which they based their medal evaluations. This was clearly supported after interpretation of the volatile chemical analysis and DA panel results, where gold medal wines were highly correlated with perceived high flavour intensity, natural red and dark fruits, and chemical compounds associated with spice, savoury, and quality oak notes, plus blue flowers and aged characters and more overt astringency and tannin. In direct contrast, no medal wines were perceived simple, less intense, jammy, and contained compounds spanning more artificial fruit characters of confectionary and banana lollies. Future research is thus warranted to examine the inter-relationships between these identified Shiraz wine sensory and chemical attributes plus rapid MIR spectra measures within wines from different quality levels and relate them back to grape composition, sensory and physical attributes. This would permit better measures of fruit quality and prediction of potential product allocation in the vineyard.

To date, the global wine industry has been more reticent than other food and beverage industries to take a market/consumer centric as opposed to a producer driven approach. Adding to earlier research that showed extrinsic cues are important for consumer purchase decisions, it was not clear how information about wine sensory properties or indeed the winery itself influenced consumers. It was shown here that as opposed to no, or basic information, elaborate information about the wine's sensory properties and the producer greatly enhanced consumer liking and willingness to pay from between approximately 20 up to 37%. Further, a sweet spot was defined for matching consumer expected liking from simply reading the information with

liking after wine tasting, resulting in maximum preparedness to pay and liking. Therefore, marketing strategies, should incorporate consumer feedback to optimise wine descriptions for web sites, menus and labels so it better reflects what is in the bottle from their point of view to enhance consumer experience. Further, differences between markets and market segments for wine flavour liking, the associated emotions and appropriate occasions for those flavours have been revealed. This may be exploited to better meet consumer needs. Future research should examine more consumption occasions and perform confirmatory trials in real life settings.

The benefits of the suggested Rate–All-That-Apply (RATA) methodology for the sensory characterisation of wines are twofold. For wine researchers, it offers a more rapid yet robust sensory profiling technique that rivals the time consuming and expensive Descriptive Analysis. Furthermore, if packaged in a suitable digital tool format in future, may also be used by industry to profile their wines and at the same time collect valuable consumer information (e.g. preferences, suitability for specific occasions). This could negate them having to outsource this analysis and if target consumers are used, offers a more consumer-centric approach, which permits producers to better communicate about their wines with their consumers in a mutually understandable language.

This project together with recent literature indicates that assessing consumers liking ratings alone are not enough to understand consumers wine related behaviour and that investigating consumers' product-evoked emotions can deliver valuable additional information. The Australian Wine Evoked Emotion Lexicon (AWEEL) developed through this project can be applied to study a wide range of wine-evoked emotional responses to gain a deeper understanding of consumers wine related behaviours such as wine choice, suitable consumption occasion, projected image.

Research on wine aroma and flavour abounds, yet mouthfeel, an important wine quality attribute, has been less well studied. From the current and earlier studies, astringency is known to affect wine consumer liking and emotions, and expert quality ratings. Practically, perception of astringency is difficult to assess from a palate fatigue standpoint and working with polyphenolic compounds is technically difficulty. Nevertheless, more research is needed to study consumer astringency perception more comprehensively. Astringency research in our group is continuing with WA funded PhD student Wenyu Kang, who is examining astringency sub-qualities and improved methods of astringency sensory assessment for research.

The intriguing finding that consumers define wine body as a holistic flavour percept, as opposed to a textural mouthfeel (trigeminal) sensation. It is clear from this project and the limited scientific research available, that a less ambiguous definition of wine body and an increased understanding of what parameters drive this sensation are required. A University of Adelaide funded viticulture and oenology coursework Masters Research student in our laboratory has been examining physical measures of commercial wines in an attempt to unravel this paradox, but more research into the mechanism of perception is required.

The Australian wine industry has long been considered at the forefront of viticulture and winemaking research. The knowledge and tools derived from this project will allow the Australian wine industry to generate improved consumer insights. By being more in tune with consumers' needs, along with their already extensive knowledge in viticulture practices and wine production, will ensure their global recognition as international market leaders and innovators.

9. Appendix 1: Communication:

Research findings have been formally communicated via publication in peer-reviewed scientific and industry technical journals, and presentations at national and international conferences. Media releases associated with peer reviewed publications were very successful and articles promoting our work were published in a wide range of newspapers, radio interviews and blogs including The Times (UK), The Telegraph (UK), The Independent (UK), Business Standard (India), New York Post (USA) etc.

9.1. Publication in peer-reviewed journals

1. Danner L., Johnson T.E., Ristic R., Meiselman H.L., Bastian S.E.P. (2017). “I Like the Sound of That!" Wine descriptions influence consumers' expectations, liking, emotions and willingness to pay for Australian white wines. *Food Research International*. 99, 263–274. *https://doi.org/10.1016/j.foodres.2017.05.019*

2. Jiang, W., Niimi, J., Ristic, R., & Bastian, S.E.P. (2017). The effects of immersive context and wine flavor on consumer wine flavor perception and elicited emotions. *American Journal of Enology and Viticulture*, 68, 1–10. *https://doi.org/10.5344/ajev.2016.16056*

3. Niimi, J., Danner, L., Li, L., Bossan, H., & Bastian, S.E.P. (2017). Wine consumers’ subjective responses to wine mouthfeel and understanding of wine body. *Food Research International*. 99, 115-122. *https://doi.org/10.1016/j.foodres.2017.05.015*

4. Danner, L., Ristic, R., Johnson, T.E., Meiselman, H. L., Hoek, A.C., Jeffery, D.W., & Bastian, S.E.P. (2016). Context and wine quality effects on consumers’ mood, emotions, liking and willingness to pay for Australian Shiraz wines. *Food Research International*, 89, 254–265. *https://doi.org/10.1016/j.foodres.2016.08.006*

5. Ristic, R., Cozzolino, D., Jeffery, D.W., Gambetta, J.M., & Bastian, S.E.P. (2016). Prediction of phenolic composition of Shiraz wines using attenuated total reflectance mid-infrared (ATR-MIR) spectroscopy. *American Journal of Enology and Viticulture*. 67, 460-465. *https://doi.org/10.5344/ajev.2016.16030*

6. Ristic, R., Johnson, T.E., Meiselman, H.L., Hoek, A. C., & Bastian, S.E.P. (2016). Towards development of a Wine Neophobia Scale (WNS): Measuring consumer wine neophobia using an adaptation of The Food Neophobia Scale (FNS). *Food Quality and Preference*, 49, 161–167. *https://doi.org/10.1016/j.foodqual.2015.12.005*

7. Niimi, J., Liu, M., Bastian. S.E.P. (accepted). Flavour-tactile cross-modal sensory interactions: the case for astringency. *Food Quality and Preference*, accepted July 4, 2017

8. Danner, L., Crump, A.M., Croker, A., Gambetta, J.M., Johnson, T.E., Bastian S.E.P. Comparison of Rate-All-That-Apply (RATA) and Descriptive Analysis (DA) for the Sensory Profiling of Wine. (2018). *American Journal of Enology and Viticulture.* 69(1), 12–21. https://doi.org/10.5344/ajev.2017.17052

9. Ristic, R., Danner, L., Johnson, T.E., Meiselman, H.L., Hoek, A., Jiranek, V., Bastian, S.E.P. (submitted). Wine consumers' hedonic and emotional responses to wine-related aromas for different seasons and contexts: a cross-cultural study. *Food Quality and Preference*

9.2. Conference presentations

Danner L., Ristic R., Hoek A., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2016). The effect of consumers' moods on product-evoked emotions and hedonic evaluation - the example of Australian Shiraz wines. 7th European Conference on Sensory and Consumer Research (Eurosense), Dijon, France

Danner L., Ristic R., Hoek A., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2016). Relationships between wine consumers' fine wine behaviour and their moods, product-evoked emotions, liking and willingness to pay for Australian Shiraz wine: A segmentation study. 7th European Conference on Sensory and Consumer Research (Eurosense), Dijon, France

Danner L., Ristic R., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2016). Distinct white wine flavours evoke different emotions in consumers. 16th Australian Wine Industry Technical Conference, Adelaide, Australia

Danner L., Ristic R., Hoek A., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2016). Relationships between wine consumers' fine wine behaviour and their moods, product-evoked emotions, liking and willingness-to-pay. 16th Australian Wine Industry Technical Conference, Adelaide, Australia

Danner L., Ristic R., Jeffery D.W., Meiselman H.L., Gambetta J.M., Johnson T.E, Bastian S.E.P. (2016). Sensory attributes and chemical components underpinning consumer and expert quality perception of Australian Shiraz wines.16th Australian Wine Industry Technical Conference, Adelaide, Australia

Danner L., Ristic R., Hoek A., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2016). Shiraz wine quality and consumption context effects on consumer emotions, liking and willingness to pay. 16th Australian Wine Industry Technical Conference, Adelaide, Australia

Danner L., Ristic R., Hoek A., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2015). Effects of red wine quality and consumption context on Australian red wine consumer emotions, liking and willingness to pay. Crush, the grape and wine science symposium, Adelaide, Australia

Danner L., Ristic R., Hoek A., Jeffery D.W., Meiselman H.L., Johnson T.E, Bastian S.E.P. (2015). Red wine quality and consumption context: effects on Australian red wine consumer emotions, liking and willingness to pay. 11th Pangborn Sensory Science Symposium, Gothenburg, Sweden

Danner L., Ristic R., Hoek A., Jeffery D.W., Gambetta J.M., Johnson T.E, Bastian S.E.P. (2015). Sensory and chemical components that underpin Australian Shiraz wine quality perception. 11th Pangborn Sensory Science Symposium, Gothenburg, Sweden

Ristic, R., Cozzolino, D., Gambetta. J.M., Jeffery, D.W. and Bastian, S.E.P. (2015). Prediction of phenolic composition of Shiraz wines using attenuated total reflectance mid-infrared (ATR-MIR) spectroscopy. 9th Edition of the In Vino Analytica Scientia Symposium IVAS, Trento, Italy

Ristic, R., and Bastian S.E.P. (2014). Which flavours wine consumers like and why. Crush, the grape and wine science symposium, Adelaide, Australia

Ristic, R., Johnson, T.E., Meiselman, H.L., Hoek, A. and Bastian S.E.P. (2014). The Wine Neophobia Scale (WNS). SenseAsia, The Asian Sensory and Consumer Research Symposium, Singapore

Ristic, R., Johnson, T.E., Meiselman, H.L., Hoek, A. and Bastian S.E.P. (2014). Global Wine Flavour Preferences: A Cross-Cultural Study. SenseAsia, The Asian Sensory and Consumer Research Symposium, Singapore

Ristic, R., Johnson, T.E., Meiselman, H.L., Hoek, A. and Bastian S.E.P. (2014). The Wine Neophobia Scale (WNS). 5th European Conference on Sensory and Consumer Research (Eurosense), Copenhagen, Denmark

Ristic, R., Johnson, T.E., Meiselman, H.L., Hoek, A. and Bastian S.E.P. (2014). Global Wine Flavour Preferences: A Cross-Cultural Study. 5th European Conference on Sensory and Consumer Research (Eurosense), Copenhagen, Denmark

9.3. Industry journal publications

Bastian, S., Ristic, R., Johnson, T. and Hoek, A. (2014) Consumer insights: Feeling the flavour: The wine industry gets emotional. *Wine and Viticulture Journal*, 29 (2), 64-65.

10. Appendix 2: Intellectual Property

The intellectual property generated from this project encompasses knowledge and know how regarding: (i) the intrinsic factors driving consumer preferences for wines and wine flavours for specific occasions in the Australian, USA and UK wine markets; ii) the extent to which wine constituents (e.g. basic chemical, polyphenol and volatile compounds) and the sensory attributes (e.g. aroma, flavour, taste, mouthfeel properties) influence quality of Australian Shiraz from the perspectives of the wine consumer and wine expert; (iii) the sensory attributes driving consumer preferences, emotions and willingness to pay for different Shiraz wines and (iv) the impacts of context effects and extrinsic factors on wine consumers moods, wine elicited emotions and liking and purchase behaviour. There may be the requirement with regards to the novel, consumer profiling methodology to be registered or subject to other forms of IP protection. However, most of the project's research findings are expected to be published in peer-reviewed scientific journals and industry journals.

11. Appendix 3: References

Barber, N., Almanza, B. A., & Donovan, J. R. (2006). Motivational factors of gender, income and age on selecting a bottle of wine. *International Journal of Wine Marketing*, *18*(3), 218–232. https://doi.org/10.1108/09547540610704774

Barber, N., Ismail, J., & Taylor, D. C. (2007). Label fluency and consumer self-confidence. *Journal of Wine Research*, *18*(2), 73–85. https://doi.org/10.1080/09571260701660847

Bastian, S. E. P., Collins, C., & Johnson, T. E. (2010). Understanding consumer preferences for Shiraz wine and Cheddar cheese pairings. *Food Quality and Preference*, *21*(7), 668–678. https://doi.org/10.1016/j.foodqual.2010.02.002

Blake, A., Kotseridis, Y., Brindle, I. D., Inglis, D., & Pickering, G. J. (2010). Effect of light and temperature on 3-alkyl-2-methoxypyrazine concentration and other impact odourants of Riesling and Cabernet Franc wine during bottle ageing. *Food Chemistry*, *119*(3), 935–944. https://doi.org/10.1016/j.foodchem.2009.07.052

Cardello, A. V. (1995). Food quality: Relativity, context and consumer expectations. *Food Quality and Preference*, *6*(3), 163–170. https://doi.org/10.1016/0950-3293(94)00039-X

Chaney, I. (2000). External search effort for wine. *International Journal of Wine Marketing*, *12*(2), 5–21. https://doi.org/10.1108/eb008711

Chrea, C., Grandjean, D., Delplanque, S., Cayeux, I., Le Calve, B., Aymard, L., … Scherer, K. R. (2009). Mapping the semantic space for the subjective experience of emotional responses to odors. *Chemical Senses*, *34*(1), 49–62. https://doi.org/10.1093/chemse/bjn052

Crump, A. M., Johnson, T. E., Wilkinson, K. L., & Bastian, S. E. P. (2015). Influence of Oak Maturation Regimen on Composition, Sensory Properties, Quality, and Consumer Acceptability of Cabernet Sauvignon Wines. *Journal of Agricultural and Food Chemistry*, *63*(5), 1593–1600. https://doi.org/10.1021/jf5044025

Dalenberg, J. R., Gutjar, S., ter Horst, G. J., de Graaf, K., Renken, R. J., & Jager, G. (2014). Evoked emotions predict food choice. *PLoS ONE*, *9*(12), e115388. https://doi.org/10.1371/journal.pone.0115388

Danner L., Johnson T.E., Ristic R., Meiselman H.L., Bastian S.E.P. (2017). “I Like the Sound of That!" Wine descriptions influence consumers' expectations, liking, emotions and willingness to pay for Australian white wines. *Food Research International, 99*, 263–274. https://doi.org/10.1016/j.foodres.2017.05.019

Danner, L., Crump, A.M., Croker, A., Gambetta, J.M., Johnson, T.E., Bastian S.E.P.

Comparison of Rate-All-That-Apply and Descriptive Analysis for the Sensory Profiling of Wine. (2018). *American Journal of Enology and Viticulture*, *69*(1), 12–21. https://doi.org/10.5344/ajev.2017.17052

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, *64*, 81–90. https://doi.org/10.1016/j.foodres.2014.06.003

Danner, L., Ristic, R., Johnson, T. E., Meiselman, H. L., Hoek, A. C., Jeffery, D. W., & Bastian, S. E. P. (2016). Context and wine quality effects on consumers' mood, emotions, liking and willingness to pay for Australian Shiraz wines. *Food Research International*, *89*, 254–265. https://doi.org/10.1016/j.foodres.2016.08.006

Delarue, J. (2015). The use of rapid sensory methods in R&D and research: an introduction. In J. Delarue, B. Lawlor, & M. Rogeaux (Eds.), *Rapid sensory profiling techniques and related methods* (1st ed., pp. 3–25). Woodhead Publishing Limited. https://doi.org/http://dx.doi.org/10.1533/9781782422587.1.3

Ferrarini, R., Carbognin, C., Casarotti, E. M., Nicolis, E., Nencini, A., & Meneghini, A. M. (2010). The emotional response to wine consumption. *Food Quality and Preference*, *21*(7), 720–725. https://doi.org/10.1016/j.foodqual.2010.06.004

Flynn, L. R., & Goldsmith, R. E. (1999). A Short, Reliable Measure of Subjective Knowledge. *Journal of Business Research*, *46*(1), 57–66. https://doi.org/10.1016/S0148-2963(98)00057-5

Francis, L., Osidacz, P., Bramley, B., King, E., O'Brien, V., Curtin, C., … Pretorius, I. S. (2010). Linking wine flavour components, sensory properties and consumer quality perceptions. *Australian and New Zealand Wine Industry Journal*, *25*(5), 18–23.

Gawel, R., Oberholster, A., & Francis, L. (2000). A "mouth-feel wheel": Terminology for communicating the mouth-feel characteristics of red wine. *Australian Journal of Grape and Wine Research*, *6*(3), 203–207.

Gawel, R., Smith, P. A., & Waters, E. J. (2016). Influence of polysaccharides on the taste and mouthfeel of white wine. *Australian Journal of Grape and Wine Research*, *22*, 350–357. https://doi.org/10.1111/ajgw.12222

Gillespie, R., & Clarke, M. (2015). Economic contribution of the australian wine sector. Economic contribution of the Australian Wine Sector.

Hersleth, M., Mevik, B. H., Næs, T., & Guinard, J. X. (2003). Effect of contextual factors on liking for wine - Use of robust design methodology. *Food Quality and Preference*, *14*(7), 615–622. https://doi.org/10.1016/S0950-3293(02)00190-8

Iland, P., Bruer, N., Edwards, G., Weeks, S., & Wilkes, E. (2004). *Chemical analysis of grapes and wine: Techniques and concepts*. Adelaide, Australia: Patrick Iland Wine Promotions Pty Ltd.

Jackson, R. S. (2009). *Wine tasting: a professional handbook*. London, UK: Academic Press.

Jiang, W., Niimi, J., Ristic, R., & Bastian, S. E. P. (2017). The effects of immersive context and wine flavor on consumer wine flavor perception and elicited emotions. *American Journal of Enology and Viticulture*, *68*, 1–10. https://doi.org/10.5344/ajev.2016.16056

Kelly, K., & Hyde, J. (2015). U.S. wine consumer preferences for bottle characteristics, back label extrinsic cues and wine composition. *Asia Pacific Journal of Marketing and Logistics*, *27*(4), 516–534. https://doi.org/http://dx.doi.org/10.1108/JEIM-07-2014-0077

King, S. C., & Meiselman, H. L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference*, *21*(2), 168–177. https://doi.org/10.1016/j.foodqual.2009.02.005

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food, principles and practices* (2nd ed.). New York: Springer.

Le Fur, Y., Teyssot, É., Foz, N. V., Fours, É., Bras, G. Le, Fant, C., & Robillard, B. (2013). Deux approches sensorielles autour du concept gras / volume dans les vins blancs et les vins rouges. *Revue Des Oenologues*, *d*, 1–6.

Lockshin, L., & Corsi, A. M. (2012). Consumer behaviour for wine 2.0: A review since 2003 and future directions. *Wine Economics and Policy*, *1*(1), 2–23. https://doi.org/10.1016/j.wep.2012.11.003

Mojet, J., Dürrschmid, K., Danner, L., Jöchl, M., Heiniö, R.-L., Holthuysen, N., & Köster, E. (2015). Are implicit emotion measurements evoked by food unrelated to liking? *Food Research International*, *76*, 224–232. https://doi.org/10.1016/j.foodres.2015.06.031

Moussaoui, K. A., & Varela, P. (2010). Exploring consumer product profiling techniques and their linkage to a quantitative descriptive analysis. *Food Quality and Preference*, *21*(8), 1088–1099. https://doi.org/10.1016/j.foodqual.2010.09.005

Mueller, S., Lockshin, L., Saltman, Y., & Blanford, J. (2010). Message on a bottle: The relative influence of wine back label information on wine choice. *Food Quality and Preference*, *21*(1), 22–32. https://doi.org/10.1016/j.foodqual.2009.07.004

Niimi, J., Danner, L., Li, L., Bossan, H., & Bastian, S.E.P. (2017). Wine consumers' subjective responses to wine mouthfeel and understanding of wine body. *Food Research International*, *99*, 115-122. https://doi.org/10.1016/j.foodres.2017.05.015

Noble, A. C., Arnold, R. A., Buechsenstein, J., Leach, E. J., Schmidt, J. O., & Stern, P. M.

(1987). Modification of a standardized system of wine aroma terminology. *American Journal of Enology and Viticulture*, *38*(2), 143–146. https://doi.org/10.1073/pnas.0703993104

Nurgel, C., & Pickering, G. (2005). Contribution of glycerol, ethanol and sugar to the perception of viscosity and density elicited by model white wines. *Journal of Texture Studies*, *36*(3), 303–323. https://doi.org/10.1111/j.1745-4603.2005.00018.x

Parr, W. V, Heatherbell, D., & White, K. G. (2002). Demystifying wine expertise: olfactory threshold, perceptual skill and semantic memory in expert and novice wine judges. *Chemical Senses*, *27*(8), 747–755. https://doi.org/10.1093/chemse/27.8.747

Pickering, G. J., & Demiglio, P. (2008). The White Wine Mouthfeel Wheel: A Lexicon for Describing the Oral Sensations Elicited by White Wine. *Journal of Wine Research*, *19*(1), 51–67. https://doi.org/10.1080/09571260802164038

Pliner, P., & Hobden, K. (1992). Development of a Scale to Measure Neophobia in Humans the Trait of Food. *Appetite*, *19*(2), 105–120. https://doi.org/10.1016/0195-6663(92)90014-W

Plummer, J. T. (1974). The Concept and Application of Life Style Segmentation. *Source: Journal of Marketing*, *38*(1), 33–37. https://doi.org/10.2307/1250164

Pollnitz, A. P., Pardon, K. H., & Sefton, M. A. (2000). Quantitative analysis of 4-ethylphenol and 4-ethylguaiacol in red wine. *Journal of Chromatography A*, *874*(1), 101–109. https://doi.org/10.1016/S0021-9673(00)00086-8

Pollnitz, A. P., Pardon, K. H., Sykes, M., & Sefton, M. A. (2004). The effects of sample preparation and gas chromatograph injection techniques on the accuracy of measuring guaiacol, 4-methylguaiacol and other volatile oak compounds in oak extracts by stable isotope dilution analyses. *Journal of Agricultural and Food Chemistry*, *52*(11), 3244–3252. https://doi.org/10.1021/jf035380x

Porcherot, C., Delplanque, S., Planchais, A., Gaudreau, N., Accolla, R., & Cayeux, I. (2012). Influence of food odorant names on the verbal measurement of emotions. *Food Quality and Preference*, *23*(2), 125–133. https://doi.org/10.1016/j.foodqual.2011.07.006

Richins, M. L. (1997). Measuring emotions in the consumption experience. *Journal of Consumer Research*, *24*(2), 127–146. https://doi.org/10.1086/209499

Ristic, R., Johnson, T. E., Meiselman, H. L., Hoek, A. C., & Bastian, S. E. P. (2016). Towards development of a Wine Neophobia Scale (WNS): Measuring consumer wine neophobia using an adaptation of The Food Neophobia Scale (FNS). *Food Quality and Preference*, *49*, 161–167. https://doi.org/10.1016/j.foodqual.2015.12.005

September 2016 Export Report. (2016). Retrieved January 12, 2017, from https://www.wineaustralia.com/au/news/media-releases/wine-australia-export-report-september-2016

Sherman, S., & Tuten, T. (2011). Message on a bottle: the wine label's influence. *International Journal of Wine*, *23*(3), 221–234. https://doi.org/http://dx.doi.org/10.1108/17511061111163050

Siebert, T. E., Solomon, M. R., Pollnitz, A. P., & Jeffery, D. W. (2010). Selective determination of volatile sulfur compounds in wine by gas chromatography with sulfur chemiluminescence detection. *Journal of Agricultural and Food Chemistry*, *58*(17), 9454–9462. https://doi.org/10.1021/jf102008r

State of Australian Wine: Results of the 2015, Wine Production, Inventory and Domestic Sales Survey. (2016). Wine Australia. State of Australian wine: Results of the 2015 wine production, inventory and domestic sales survey.

Stone, H., & Sidel, J. (1993). *Sensory Evaluation Practices.* (3rd ed.). London: Elvier.

Tang, V. C. M., Tchetchik, A., & Cohen, E. (2015). Perception of wine labels by Hong Kong Chinese consumers. *Wine Economics and Policy*, *4*(1), 12–21. https://doi.org/10.1016/j.wep.2015.02.002

Thomas, A., & Pickering, G. (2005). X-it: Gen-X and older wine drinker comparisons in New Zealand. *International Journal of Wine Marketing*, *17*(2), 30–48. https://doi.org/http://dx.doi.org/10.1108/17511061111142981

Valentin, D., Chollet, S., Lelièvre, M., & Abdi, H. (2012). Quick and dirty but still pretty good: A review of new descriptive methods in food science. *International Journal of Food Science and Technology*, *47*(8), 1563–1578. https://doi.org/10.1111/j.1365-2621.2012.03022.x

van Zyl, H., & Meiselman, H. L. (2015). The roles of culture and language in designing emotion lists: Comparing the same language in different English and Spanish speaking countries. *Food Quality and Preference*, *41*, 201–213. https://doi.org/10.1016/j.foodqual.2014.12.003

van Zyl, H., & Meiselman, H. L. (2016). An update on the roles of culture and language in designing emotion lists: English, Spanish and Portuguese. *Food Quality and Preference*, *51*, 72–76. https://doi.org/10.1016/j.foodqual.2016.02.019

Vidal, L., Giménez, A., Medina, K., Boido, E., & Ares, G. (2015). How do consumers describe wine astringency? *Food Research International*, *78*, 321–326. https://doi.org/10.1016/j.foodres.2015.09.025

12. Appendix 4: Staff

The University of Adelaide

- Dr Susan Bastian, Associate Professor in Oenology and Sensory Studies, PhD, 20%
- Dr David Jeffery, Associate Professor in Wine Science, PhD, 20%
- Dr Vladimir Jiranek, Professor in Oenology, PhD, 10%
- Dr Paul Grbin, Senior Lecturer in Wine Science, PhD, 20%
- Dr Renata Ristic, CI, PhD, 100% (2013-2014)
- Dr Lukas Danner, CI, Dr, 100% (2015-2017)

University of South Australia

- Dr Annet Hoek, Lecturer in Nutrition, PhD, 20%

13. Appendix 5: Other relevant material

Media release by the University of Adelaide associated with Danner et al. 2017

Media Release
www.adelaide.edu.au/news

THE UNIVERSITY of ADELAIDE

Wednesday 7 June 2017

Wine descriptions make us more emotional about wine

Research by the University of Adelaide has shown that consumers are much more influenced by wine label descriptions than previously thought.

A consumer study by wine researchers at the University's School of Agriculture, Food and Wine has shown that far more than just influencing consumer choice, wine descriptions can alter consumer emotions, increase their wine liking and encourage them to pay more for a bottle. The study has been published in the journal *Food Research International*.

"Choosing the right wine at the point of sale whether in a wine store, in a restaurant or online can be a difficult task," says project leader Associate Professor Sue Bastian.

"The importance of wine labels and label information has been widely studied and it's been clearly shown that they represent useful information which influences consumer choice. Our study extends these findings, showing that wine descriptions also influence our whole wine consumption experience."

"Cleverly written wine and producer descriptions when coupled with unbranded wine tasting can evoke more positive emotions, increasing our positive perception of the wine, our estimation of its quality and the amount we would be willing to pay for it."

The researchers conducted a study with Australian white wines and 126 regular white wine consumers. The consumers evaluated the same set of three commercially available white wines (Chardonnay, Riesling and Sauvignon Blanc) under three information levels: a blind tasting with no information; the provision of a basic sensory description; and provision of an elaborate/emotional description.

The presentation of more elaborate wine descriptions, which included information regarding winery history and positive wine quality statements, significantly increased the preference rating the consumers allocated to the wines.

Further to this, the results showed that if the expectations elicited by the wine description closely matched the actual liking from tasting, consumers felt far more positive emotions than if it didn't meet expectations.

"These findings have important implications for wine producers and the hospitality industry in that descriptions require more than just wine tasting notes," says Dr Lukas Danner, post-doctoral research fellow and first author on the study. "Companies could even consider involving consumers in label description optimisation."

This research was funded by Australian grapegrowers and winemakers through Wine Australia with matching funds from the Australian Government.

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Figure 31: Altmetrics ranking from the Food Research International Journal.