Advanced Wine Assessment Course

AWRI

Course Notes

The Australian Wine Research Institute Ltd
ABN 83 007 558 296
Corner of Hartley Grove and Paratoo Road
Urrbrae SA 5064
Australia

PO Box 197
Glen Osmond SA 5064
Australia
Website: www.awri.com.au
Telephone: +61 8 8313 6600
Email: enquiries@awri.com.au

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The Advanced Wine Assessment Course: course notes

1. Why are we here?

The objective of the Advanced Wine Assessment Course is to prepare potential new wine show judges for judging wines in the Australian wine show system. The AWAC will:

- provide training in the techniques and practices of wine show judging
- investigate and challenge the criteria on which tasters make decisions on wine quality and preference
- improve participants ability to communicate clearly and effectively with other judges and to justify reasoning for allocating wines at different quality levels
- improve participants appreciation and recognition of different wine styles, blends or regional (GI) character
- provide a statistical evaluation of tasting performance measurements on wine quality assessment, with respect to:
    - discrimination - the degree to which wines of different quality levels are separated based on quality score
    - reliability - a measure of scoring consistency, or the ability of a judge to reproduce results on different tasting occasions
    - absolute average difference – a more straightforward measure of consistency. It is the average difference between scores given to wines on repeat tastings
    - stability - a measure of propensity to systematically score wines higher or lower on the second tasting relative to the first.

The AWAC course is often the first step for experienced wine industry professionals on a journey toward becoming a wine judge. The AWAC aims to 'prepare' rather than 'train' potential new judges, as the skills and experience required to judge at a wine show cannot, to a certain extent, be taught - especially within a four-day period. Participants should thus already have considerable formal wine tasting experience before enrolling in the course. The course is deliberately intended to be rigorous and challenging for participants, however few people have difficulty with the pace or content of the course, especially if they approach the tastings in an organised and methodical manner as instructed. Feedback from past participants indicates that many people feel that they approach wine tasting and evaluation differently after having completed the course.

The structure of the course includes initial wine flavour, taint and fault sensitivity training followed by palate alignment brackets. Palate alignment brackets are intended to both familiarise participants with the current wine quality scoring system approach used in the course and to compare their judging of wines to those of guest judges. The remainder of the course will include simulated wine show-class tasting brackets to reflect tasting brackets that would currently be found in a wine show but also tastings of more diverse and mixed wine styles that do not fit the classic wine show mould. These later exercises are aimed at challenging the basis on how you rate individual wines for quality. Participants will be expected to talk about wines in each of the tasting brackets, and to justify to the class and guest judges why they have given the wine a particular quality score. Don't be intimidated - the discussions are run in a friendly and cooperative manner, with everybody learning from each other. Remember, everybody will make mistakes along the way - we all do (including the guest judges) and this is part of the learning process.

Upon completion of the AWAC course, participants will have insight into their current sensory evaluation physiological strengths and weaknesses, wine quality differentiation and wine communication skills and potentially highlight areas for improvement in wine judging. It needs to be emphasised that statistical evaluation of your tasting performance is intended to raise your awareness, confidence and understanding of your own tasting ability. However, it should also be remembered that the course is only a 'snapshot' of your sensory performance over a four-day period and that the performance of individual judges is, to some degree, likely to change from one occasion to another.

2. What are the objectives of show judging?

Since the first referenced Australian wine show in 1826, the objectives of wine shows have evolved considerably, particularly in the last 30 years. In 1986, the Australian Society of Viticulture and Oenology (ASVO) published the first *Australian Wine Show Model Standards*, which has since been revised in 2004, 2015 and again in 2020. Initially wine shows were viewed as a mechanism to "improve the breed" of Australian wine. Today wine show competitions drive the evolution of Australian wine styles, including the recognition of diversity within each style, blend or regional (GI) character and reward the continuous improvement in quality and excellence within each wine style.

Celebrating the diversity of character arising from the same varieties grown in different Australian regions (GIs) is an important platform for the re-imaging of Australian wines in world markets. The Australian wine show system ASVO Best Practice Guidelines infer a level of rigour and robustness to Australian wine shows and offer a reliable information platform to communicate to trade and global consumers about the diversity and quality of Australian wines that receive awards.

The AWAC plays an integral role in providing adequately prepared wine show judges for the Australian wine show system. Participants will thus develop an appreciation of wine excellence in both Australian and international regional wine styles, challenge any style prejudices, and focus on the fundamentals of what wine quality really is.

3. The approach of this course

AWAC uses the electronic scoring system Show*Runner*. You will use your own device (Tablet or Laptop) to record both wine scores and tasting notes for each wine throughout the course. Instructions and demonstrations are provided on how to use the software on the device to ensure you are comfortable with the system before we commence any judging.

The first tasting session, or Class 1, is an introductory evaluation to common wine flavours, taints and faults. Recognising the major flavour compounds found in different wine styles and the most common wine faults and taints found in wine, and knowing your own sensitivities or anosmias to any of these compounds, is a necessary tool for any wine show judge. As a wine show judge it is crucial that you are able to identify the most common wine faults and taints quickly. Experienced judges will tell you **"don't waste time on the faulty and poor quality wines"** – it is better to use that time to discriminate more finely between the better wines. This will be a recurring theme over the four days.

The second tasting, Class 2, is designed to:

- familiarise you with the wine show judging process
- practice using Show*Runner* software for wine show judging
- to determine what are the intrinsic qualities that distinguish gold or silver medal wines against others that may only be awarded a bronze, or no medal

Wines have been replicated from a recent wine show, and you will find a mix of Gold, Silver and Bronze medal awarded wines alongside wines which did not receive a medal. You will taste the wines alongside invited guest judges. After tasting, the guest judges will then guide you through their reasoning of why wines have been awarded different quality levels. This is the opportunity to ask questions, compare your judging and assessment of wine quality against the guest judges or class and make any necessary adjustments to your judging style. This tasting is designed deliberately to be a learning exercise and no wines are included in the statistical evaluation of your tasting performance.

This afternoon includes four varietal tastings. Class 3 and 4 could be considered benchmarking brackets. Use the tastings to further tease out what are the intrinsic qualities which judges look for when deciding which medal to award. Amongst the ten wines in each varietal bracket will again be wines that won a Trophy, Gold, Silver and Bronze medal as well as wines that may not have been not awarded a medal at recent wine shows. These tastings may also include acclaimed Australian and imported benchmark wines from each variety to highlight the diversity that can occur in each varietal. A very broad range of wine styles, quality levels at all price points will be presented during the course and it will be important for participants to be able to recognise high quality wines and reward them accordingly and conversely, to down-point those of lower quality.

Over 3 minutes has been allowed for the tasting of each wine on this first day. Whilst some participants may find this pace challenging at first, bear in mind that the average tasting time allowed for each wine will be steadily decreased throughout the course to around 2 minutes per wine. Most participants are surprised at how their judging speed increases as the course progresses.

Once you have tasted the wines this is followed by a class discussion about each wine in turn. The scores apportioned by participants and guest judges are revealed on a central screen, and you will have another opportunity to retaste or evaluate the wine further as the wine is discussed.

Everyone will be expected and asked to express their opinion on at least one or two of the wines during each tasting; for both wines that they awarded medals to and those that they did not. Communication is an important aspect of wine show judging so expect to justify or provide clear reasoning on why you awarded a wine a particular score or medal.

Throughout the course, some wines from Classes 3-15 will be repeated within and between brackets and across days. Participants' scores for these wines will be used for statistical evaluation of quality differentiation and repeatability. International wines may be included in any of the brackets across the four days however scores given to these wines will not be used in the statistical evaluation. It is very important that you do not try to identify any repeated wines within brackets. From extensive experience with both quality scoring and formal sensory analysis panels, this has been found to be a strategy that is not successful. The best approach for optimal concentration, focus and consistent scoring is to treat each wine as an individual wine in the glass and work on scoring wines in a consistent way.

It is not possible to completely replicate wine show conditions on the course, or to strictly follow show specifications for each class. We want to expose participants to as wide a range of wine styles as possible during the course. Therefore, you should expect to find a mix of varieties in some classes where no variety is specified, or a mix of vintages in some varietal classes, and even some wines that some might consider being out of class. Remember that as well as a range of varieties and wine ages, some brackets may also contain wines from several countries. In order to minimise bias when tasting some of the older or aged wines amongst a class of younger wines, the vintage of the oldest wine will be indicated to participants at the beginning of each tasting.

Day one is followed immediately with the course dinner - an integral part of the show-judging experience, and an integral part of this course. All participants are expected to attend the dinner which is covered by the course fee. The dinner is held on the first evening of the course to allow you to get to know your fellow participants as early in the course as possible. Participants will not have time to return to their hotel before dinner. A bus will be provided to take participants from AWRI to the dinner venue.

We encourage you to bring a bottle of wine to the dinner. This may be a wine that you have made yourself, a style that you are particularly interested in, or something that you just want to drink - after all, that is what this is all about! Please bring the bottle with you on the first day and AWRI will arrange chilling if required and transport these to the restaurant.

The panel tastings on day three seek to demonstrate the type of judging you would expect to encounter at a wine show, where wines are judged individually and then discussed in a small group to reach a consensus quality score for the wine. The smaller panels will reproduce the type of spirited discussion that can take place within judging panels in a wine show situation. A recurring theme of the course will be to encourage participants not only to score particular wines, but also to understand and to form and enunciate arguments as to why they gave a particular score. This tasting is designed to give participants the opportunity to do this and to defend their scores against those with differing opinions. Please take special note of the instructions provided below on how these tastings will work. For these tastings in particular, participants are encouraged to form strong opinions and arguments as to why they consider a wine to be of a particular quality level.

Procedure for tastings conducted with panels of five participants

The purpose of this exercise is to familiarise participants with the mechanics of the panel tasting, the process of scoring wines and allocating appropriate awards.

- The group will be divided into three panels which will include one of the guest judges. The guest judge will be designated as the chairperson. For the second and third sessions you will be allocated a different guest judge to give you an idea of different panel judging styles that you might encounter in wine shows. All participants will taste all 10 wines individually and will score them in the usual manner. No information will be provided as to the style, variety(ies), provenance or vintage.
- After the wines have been tasted, the participants of each panel will have 40 minutes to discuss and arrive at a consensus score for each wine. These scores will then be entered by the guest judge allocated as the chairperson, and the identity of the wines revealed.
- Each group returns to the tasting room and the three panels consensus scores for each wine will then be revealed, along with each panel’s preference or top-rated wine.

The wines are deliberately chosen to be diverse and perhaps polarising in nature to stimulate discussion about what is wine quality. The scores given to these wines in this session will not be used in the statistical analysis of participants’ performance.

Day four includes two larger brackets, one white and one red, each consisting of 32 wines. Not all of these wines will be Australian, but only Australian and New Zealand wines will be used for the statistical evaluation of a participant’s performance. The wines in these brackets may be of any age, variety, style and provenance. If a white wine does show residual sweetness, it should be marked accordingly and not considered as “out of class”. In this sense, this exercise is unlikely to be encountered in a show situation. However, take consolation from the fact that what you are being asked to do is in some ways more difficult than judging many wine show classes.

These tastings should be viewed as a continuation of the progression of tasting formats through which you will pass over the four days. As with all the other tastings, approach each wine as an individual.

The sweet wines bracket includes of a number of styles from around the world. This bracket has deliberately been placed at the end of the course to challenge you, your fatigue, your teeth, and to make you consider whether you are really serious about being a wine show judge after all! Whilst this may seem tough at first, we have used this format before and it has worked well, with most participants surprised at their discrimination and enjoyment of the sweet wines, after several days of wine judging.

The final tasting bracket and has been simulated to represent the 'trophy taste-off' that occurs at the conclusion of most wine shows. This tasting will consist of six wines. All of the wines will be from Australia, and all will have been awarded a trophy from a recent wine show. Whilst to some extent this activity may be a welcome and slightly light-hearted relief to the preceding tastings, it should also produce a spirited and informative discussion on the relative merits of each wine and the style or variety that it represents. Remember, your view is as valid as the next person, - so have your say. Additionally, recent experience suggests that the manner in which the 'Trophy' wine is decided by this process can also generate some spirited discussion – some people are apparently very competitive, including some of our guest judges!

A presentation is delivered at which the statistical approach taken for the Course will be described, including a summary of the analysis that is conducted on participants' scores and information on how the course results will be presented to you soon after the course is completed.

The day and course conclude with a presentation of your AWAC graduation certificate. The AWAC concludes at 17:00pm, so please take that into consideration when organising commute such as to the airport and when booking departing flight times.

You will also have the opportunity to provide course feedback at the end of the course. Your feedback is important to us to continually improve the course.

4. The ground rules

To ensure the safety of all participants, additional spacing and hygiene measures will be put in place to comply with COVID-19 government health guidelines and social distancing requirements.

The AWAC is an intensive course with many tastings, short breaks and minimal time to conduct your usual day-to-day business during the course. To ensure the course runs to time, please be aware of the following ground rules:

- be on time – it is unacceptable to interfere with the concentration of your fellow participants by arriving late for tastings and we will not delay tastings if you are not present
- turn off mobile telephones during tasting brackets
- listen and follow instructions carefully
- no talking whilst tasting
- call it as you see it

- be confident
- the first impression is often the best
- remember that the evaluation is a statistical exercise and that we all make mistakes
- above all – enjoy it – there should be some truly 'great' wines.

When you see a 'corked' wine, note as either 'corked' or 'TCA' on your tasting notes, however you must still score this wine. Bottles deemed by consensus to be corked or otherwise out of condition, will be removed from the statistical evaluation of your performance. As for most wine shows, we do not repour an extra bottle of wine if the bottle being tasted is perceived to be affected by cork taint or other problems.

Be prepared to make mistakes. Three judges are unlikely to all make the same mistake - which is one of the strengths of the current Australian wine show system. If you have made an error of judgement acknowledge it readily and learn to appreciate the characters others are judging in the wine. Having said that, it is also true that just because you are in a minority does not mean you are wrong. Keep an open mind.

Try not to be parochial. Many of us have, to a greater or lesser degree, a cellar palate or an Australian palate. We need to be open-minded to develop an international palate. It's a long and enjoyable journey. Try to submerge personal likes and dislikes and think objectively about the merits of a wine. Recognise the distinction between a technical and an aesthetic appreciation. In the event we need both - a strong aesthetic sense based on a sound technical foundation.

5. Dynamics of wine show judging

Wine tasting

Introduction

Wine judging is a form of sensory evaluation involving all the senses: sight, smell, taste, and feel and, to a certain extent, sound. It is a difficult task, even for experienced judges. Considerable concentration and application to the task at hand are mandatory.

A major part of being a good wine judge is sufficient experience with a wide range of wines of different styles and quality levels, together with a good long-term memory. The ability to recall sensory properties of wines that conform to levels of quality, especially those which are of excellent quality, is essential. A group of judges will over time develop a shared concept of quality levels for different wine types.

Tasting in the wine show environment is different to that encountered in a winery, in a laboratory, or at home. Evaluation in a specialist sensory laboratory is the most rigorous form of tasting, where wines are assessed at least in duplicate, controlling all extraneous variables, randomising presentation order across judges, and the results are subjected to statistical analysis. Obviously, duplicate tasting is not a possibility in the show system where 100 to 200 samples are assessed daily. This highlights the importance of having judges capable of giving an accurate, repeatable analysis in a minimum of time.

Sensory physiology and variations in responses between individuals

A clear example of variation in our abilities to perceive sensations arising from genetic differences is colour blindness. While not a single condition, colour blindness is much more common in males (approximately 8% of males versus 0.1% of females), and results in an inability or diminished ability to see particular colours, most commonly green. Wine tasters should be aware if they are colour blind through the use of simple tools such as the Ishihara test (Birch 2001).

Aroma

The sense of smell, which could be considered to be the most important sense for wine evaluation, is responsible for detection of chemical compounds present in the gaseous phase: compounds that are volatile. We can recognise and remember up to 10,000 different aromas and most of the complex sensory information we receive when tasting a wine will arise from the sense of smell. It operates during wine tasting whether the wine is being smelled in the glass or tasted in the mouth. During tasting, volatile compounds from the wine move in the vapour phase from the mouth through the retro nasal passage at the back of the oral cavity and into the nasal cavity, where odorous molecules in the mixture are detected by receptor cells in the small (approx. one cm^2) area of olfactory epithelium of each nostril. Holding the nose while tasting, or when the nose is blocked (for example, due to a head cold), will severely limit the flow of air from the mouth to the olfactory epithelium. Any food or wine that is tasted under such conditions will seem bland due to the lack of detection of volatile compounds. Odorants move through the (aqueous) mucus secretion covering the olfactory epithelium and interact with olfactory cilia, which are part of elongated olfactory receptor cells. In humans the surface area of the cilia is considerable, approximately 22 cm^2; however, this is small compared to the several square *metres* of corresponding tissue possessed by dogs (Doty 2001). We possess more than 100 million receptor cells, of approximately 1,000 different types, each encoded by a specific gene. Around three percent of our genes are involved in coding for the different odour receptor cells, each of which has only one type of olfactory receptor, and which are continuously regenerated by the body (Buck 2005). There is wide genetic variation in receptor cells across humans.

Each odour receptor cell can interact with more than one type of odorant molecule, although each odorant capable of binding with a given cell will have some common characteristic. As nearly all odours are made up of many different odorant compounds, each individual compound in the mixture will bind to several odorant receptors so that a pattern of electrical signals will be produced for an aroma. It is the pattern that we can recognise and learn to name as a specific smell.

The sense of smell is very sensitive, able to detect exceedingly low levels of some particular aroma compounds. An individual's 'threshold' of perception for a certain volatile compound, i.e. the lowest amount needed to be present to give a detectable smell, varies greatly among individuals (Doty 2003).

It is not unusual for a person to be relatively insensitive to a particular compound or aroma (such as diacetyl, the butter-like aroma compound produced by some bacteria and yeast), yet be very sensitive to another, such as compounds responsible for 'mousy' taint in wine. In a practical sense, this variation among individuals means that when a task involves assessment of wines for particular faults or off-flavours, it is important to have some understanding of a taster's particular insensitivities, ideally gained by a process of screening using standard wines with added compounds.

Interpreting information about an individual's specific sensitivities can be difficult. While an individual may be very sensitive to a compound at low concentration (i.e. have a low threshold), their ability to detect the same compound at higher concentration may not be better than the average population (Lawless et al. 1995). Simply because individuals in a group may vary in their ability to detect an aroma-active compound, they should not be excluded from a panel. As indicated above, it is very likely that every potential judge, no matter how experienced in wine assessment, will have some relative inability to detect a specific compound, and unless the aim of the assessment is to determine a particular component—such as the common taint agent 2,4,6 trichloroanisole (or 'TCA')—it is better to have a panel of judges with a broad range of physiological abilities.

An important aspect to be considered when tasting wine is the innate 'adaptation' of the sense of smell to aromas. This is easily observed in daily experience in an environment with a noticeable smell, such as a laboratory or cellar. Upon entering the room the aroma is very obvious, but after a short period it is no longer readily perceived. This adaptation phenomenon is related to the purpose of the animal sensory system, which is tuned to notice new environmental information, and which therefore removes from notice an unchanging stimulus. When tasting several wines in succession, leaving a break of 30 seconds between sniffs will act to counter the adaptation effect.

Another feature of the sense of smell is that perception is influenced by the nature of mixtures of aroma compounds. It is known that aroma compounds interact with each other, with masking or suppressing effects being probably universal for compounds at above-threshold concentrations, while additive interactions occur for compounds at sub-threshold concentrations. Thus a compound with a marginal aroma impact when in isolation, can, in concert with others of similar chemical structure, give rise to perceptible aroma.

The suppression effect is also an important aspect of aroma perception. When many compounds are present at a concentration above their individual threshold no one compound will necessarily dominate.
However, in some cases one compound may dominate the mixture so completely that others, notwithstanding their above-threshold concentration, may not be perceived at all.

Thus, the presence of a strong aroma in a tasting area may mask aromas in wines to be assessed. Conversely, it has been shown that there can be a release from suppression effect, so that when an aroma component has been adapted to, another aroma component in a mixture that may have been masked by the adapted aroma may be perceived more strongly. Due to this effect, it is possible that in a wine tasting room with a background aroma of wine, an unusual aroma in a sample might stand out more than it otherwise would.

There are a very large number of types of aromas, or 'qualities' that we come to recognise and identify. However, for most people the skill to put a name to an aroma is something that is difficult to learn and it is a very common experience, for even the most practiced individuals, to encounter smells that one knows are very familiar but the name of which cannot be recalled. This has been termed the 'tip of the nose' effect. Extensive experience and training will improve this ability, but the effect will be frequently evident.

Flavour, mouth-feel and taste

The distinction between 'flavour', which includes volatile compounds, and 'taste', is often confusing. Strictly speaking, taste only refers to the sensations perceived by the taste receptor cells within taste buds (located throughout the mouth, but largely on the tongue): sweetness, saltiness, bitterness, sourness, and the savoury taste, umami. Recent work has pointed to the possibility of fat taste receptors (Laugerette at al. 2005).

The most commonly agreed concept of 'flavour' refers to all perceptible sensations arising from placing a sample (food or beverage) in the mouth: "the attribute, produced by a complex combination of the olfactory and gustatory [taste] properties, perceived during tasting and which may be influenced by tactile, thermal, pain and even kinaesthetic [movement] effects" (Standards Australia 1989). Wine aroma is therefore the odour or smell of wine, whereas wine flavour is a combination of wine aroma, taste and texture when the wine is in the mouth or after swallowing/spitting.

It is important to clarify one important point regarding the physiology of taste: where on the tongue do we taste specific characters? The commonly represented 'map of the tongue', in which it is indicated that sweetness is perceived at the tip of the tongue, bitterness at the back, and so on, is not accurate. In fact, all basic tastes are detected on all regions of the tongue, and all of the taste buds situated throughout the tongue detect the five tastes.

While there is a very slightly higher sensitivity to bitter compounds at the back of the palate, and a slightly lower sensitivity at the front of the tongue, differences for other tastes are negligible across the tongue.

Taste receptor cells within taste buds are present over most of the tongue, as well as at the back of the soft palate and the upper part of the throat, and are sensitive to all of the tastes. There are thousands of taste buds situated in the mouth of a normal adult, found within numerous small protuberant projections called papillae. They contribute approximately 1,000 taste buds in total. The elongated taste receptor cells within taste buds have microvillae, small finger-like structures that form the taste pore where taste molecules interact with the taste bud.

There is evidence to suggest that people with greater taste sensitivity have a larger number of fungiform papillae than average, arising through natural genetic differences. The greatest impact of varying quantities of these taste buds seems to be on the perception of bitterness (Bartoshuk et al. 1999). Thus, those individuals with larger than average numbers of taste buds may be more sensitive to bitterness, and to a lesser extent sweetness, while those with a smaller number are not able to perceive such a strong taste. It has also been indicated that this relationship between numbers of taste buds and strength of a sensation relates to touch sensations such as the perception of fattiness (Bartoshuk et al. 2004). A dramatic example of the genetic differences among individuals is found in people's ability to taste the compound n-propylthiouracil (commonly abbreviated as PROP). A small part of the population cannot taste this compound, a large proportion perceive it as moderately bitter, while some find it extremely bitter (Duffy and Bartoshuk 2000).

In common with the sense of smell, the sense of taste is subject to adaptation, where, for example, the perception of sweetness diminishes during repeated tasting of a sweet wine. This adaptation phenomenon will also increase the response to other tastes: tasting sweet solutions and then tasting a bitter sample will mean the bitterness will be perceived more strongly (Lawless and Heymann 1999).

The tactile, or mouth-feel, aspects of foods and beverages are detected by touch receptors, associated with taste buds, but more widely scattered around the mouth. These sensations include product temperature, astringency, thickness or viscosity, prickling and pain, and impressions of warmth or hotness, and deserve greater attention than they have traditionally received.

Astringency can be defined as a drying, roughening and puckering mouth-feel sensation (Lawless et al. 1994), and is regarded as a tactile sensation rather than as a true taste (Gawel 1998). This idea is supported by the observation that during the tasting of successive highly astringent wines there is an increase in the astringent sensation (see Guinard et al. 1986), as opposed to tastes such as bitterness, to which we become desensitised with repeated exposure. There is good evidence that the mechanism of astringency is related to a reduction in lubrication properties of saliva due to an interaction of high molecular weight phenolic compounds ('tannin') with salivary proteins; with a further likely mechanism of direct interaction of tannins with mouth epithelial cells. It is also probably caused by the denaturing of proteins by acids (Sowalsky and Noble 1998).

Most compounds produce complicated combinations of flavour responses: even a simple solution of a single acid, while having no aroma, can be both sour and astringent; and ethanol is volatile and aromatic, as well as possessing sweet and bitter tastes and warm, viscous sensations. The interaction of compounds is complex and unpredictable, and is affected by the individual's specific responses. Some effects magnify each other:

the astringent sensation is increased at low pH, while higher alcohol enhances bitterness (Noble 1998). However, the basic tastes will suppress each other (Keast and Breslin 2003): it is well known that sweetness masks sourness, and saltiness masks bitterness. Breslin and Beauchamp (1997) showed, in a study of the interactions of saltiness, sweetness, and bitterness, that salt at a low level suppresses bitterness, but not sweetness.

Scoring wines

Wine shows predominantly score wines out of 100 or 20 points, and occasionally 60 points. The AWAC course will use the 100 point system in accordance with the ASVO Wine Show Best Practice Recommendations update, released in 2020, which recommended that most shows should adopt the 100 point system.

The 20 point Australian system was historically used in most wine shows, and whilst is made up of 20 points it is generally only used with a 7-point range, with half points allowed: from approximately 12 points for a genuinely poor wine to 19 for one of excellence (Table 1). In choosing to split these seven points into halves, we in effect use approximately 14 quality graduations. The system was developed and is commonly taught with 3 points awarded to appearance, 7 for aroma, and 10 for palate or in-mouth sensations. An average but acceptable wine with no special distinction or defects is given 3 points for appearance, 5 for aroma and 7 for palate: a total of 15 points.

The 100 point scale is generally only used with a 16-point range, with no half points allowed: from approximately 80 points for a genuinely poor wine to 96 for one of excellence (Table 1).
Wines are judged with 15 points awarded to colour and clarity, 35 points awarded for aroma, and 50 points awarded for palate or in-mouth sensations.

When first using either the 3-7-10 breakdown in the 20 point system, or the 15-35-50 breakdown in the 100 point system, in a formal judging situation, novices often try to account for each point and find themselves adding up points or half-points in order to arrive at a final total, or asking a more experienced taster what points they allocated to the colour, nose or palate. The reality is that very few, if any, experienced tasters are actually conscious of their allocation to these sub-categories. Instead, the decision that they make is to assign the wine in question to one of four fundamental groups: ‘no medal’, ‘bronze’, ‘silver’ or ‘gold’.

For the 20 point system, within each of the medals groupings there are three possible point scores: for example bronze at 15.5, 16.0 or 16.5 points. For the 100 point system, within each of the medals groupings there are five possible point scores: for example bronze at 85, 86, 87, 88, or 89 points.

The bronze-medal winning wine is allocated one of these scores according to its relative strength in that group, and a judge giving a wine 89 points is effectively telling themself that in the subsequent discussion and consensus stage, they may be inclined to elevate the wine to say 90 points, or a silver medal, if challenged. A wine receiving 85 points has, in contrast, received the lowest score possible for bronze medal eligibility, and the judge is much less likely to increase their points and agree to the wine being awarded a silver medal.

Table 1. The 100 and 20 point quality system and a suggested quality designation for the different scores provided

Points range /100	Points range /20	Medal	Quality designation	Comments
95-100	>18.5	Gold	Outstanding, exceptional	Meeting all requirements and expectations of a wine of the particular style: clear varietal or style definition, complexity, intensity, balance and persistence
90-94	17-18.4	Silver	Excellent	A very good wine, that doesn't quite meet the standard required for a gold medal, but with more distinctiveness, complexity, intensity and balance than a bronze medal wine.
85-89	15.5-16.9	Bronze	Good	A wine with a degree of distinctiveness or complexity, balance and/or intensity; free from taints or faults.
80-84	14-15.4	None	Sound or acceptable	Sound wines, free of major faults or defects, but lacking a degree of distinctiveness. The wine may have some attributes that do not meet expectations, such as excessive oak influence or slight bitterness. Simple and not to be 'rewarded'
<80	13-13.9	None	Basic	Simple or low intensity flavours; minor defects such as low-level volatile acidity or reductive character or overly dominant *Brettanomyces* flavour; lacking freshness or varietal characteristics; excessive or too little acidity; excessive bitterness or astringency.
	12-12.9	None	Marginal	As for Basic quality but defects may be more pronounced or wine less intense.
	<11.9	None	Not commercially acceptable	Obvious, dominating defects such as oxidation, sulfidic character, or having some specific taint (examples include cork taint or chlorophenol) at <u>any</u> level.

Appearance: Colour and clarity
These two elements of a wine's visual appearance are generally linked for one major reason: a hazy or cloudy wine will frequently have a different colour if clarified, due to the scattering or reflection of the light that enters the wine by the particulate matter present. The appearance will be an attribute of interest on its own, but it is

undoubtedly of particular interest as an indication of the presence of any flavour defects, notably oxidation or microbiological growth.

There is the special case of a protein unstable wine, where a hazy appearance has no sensory effect other than rendering the wine visually less attractive, and potentially indicating to a consumer through a logical link that there may be something in fact wrong with the wine (Waters et al. 2005).

Colour is generally considered as being comprised of two main elements: *hue* (or shade or tint) and *density* (or depth or intensity). Thus, a wine of brick-red hue may be quite intense in colour and be described as 'dark' (almost impossible to see through in a normal tasting glass) or 'light'.

The provision of a maximum score of three points for the 20 point system or 15 points for the 100 point system, to this area by the Australian wine show system means that it is theoretically possible for a wine with totally unacceptable colour and clarity to be allocated zero points for this aspect of quality, and still be awarded a silver medal; in reality this is almost impossible, as wines of poor colour and clarity will frequently have other problems, perceived on the nose and palate. In most cases appearance is judged as acceptable for the style, and it is uncommon for a wine to receive less than 3 points for the 20 point system.

Colour is frequently indicative of other aspects of the wine's style, age, and quality. A taster deprived of the visual stimulus of the colour of six commercial red and two white wines, was considered "lucky" or "very experienced" if they could identify the two white wines from the set (Peynaud 1987). Indeed, experienced tasters draw so many clues from the appearance of the wine that it may be appropriate in some tastings to present the wines truly 'blind', using black glasses or a tinted light source that masks the true colour of the wine.

The intensity of colour of a liquid is affected by the distance through which the light must pass; the greater the path-length of the light, the more is absorbed. This is one of the reasons why, to allow truly valid comparisons of different wines, a consistent volume of wine must be served in glasses of consistent dimensions.

Colour is almost always assessed against a white surface, which allows the accurate assessment of hue and depth without interference from the background. The assessment normally takes place in a glass filled to less than 25% of its total volume, which may be tilted to provide a gradation of depth of wine through which the wine is observed: effectively, a gradient of path-length through which the light passes.

The choice of words to describe colour should be limited to hues that are in common use, to allow an objective, repeatable description to be made, of use to another taster. This is not easy, as perceptions of colour are complex and undoubtedly subjective, and reflect the individual's experience and quality of vision. Many colour terms are used synonymously (Chapanis 1965). To minimise this problem, it is suggested that it is better to use amalgams of a few familiar words (e.g. pale straw with green tints) rather than a vast range of single terms (e.g. daffodil). But which terms? While evocative and perhaps romantic to some, obscure terms described by authors such as Peynaud (1987) such as “partridge eye”, “amaranth” and “vermilion” are less helpful than more common colours (with variations) such as violet, crimson, brick and scarlet. Jackson (2002) suggests purple, ruby, red, brick and tawny for reds, and straw, yellow, gold and amber for whites, with the use of pale, light, medium and dark to express density.

It is proposed that the following hues are adequate to describe most colours found in wine, with the adjectives pale, mid (or medium) and dark used to describe depth or intensity (degree of opaqueness) of the colour. Thus, for white wines, the terms are water-white (colourless), straw or gold, with hints (sub-tones) of: green, grey, pink or brown. Using this system, a wine will be described with three words: for example, “pale straw (with a) green (tint)”; or “dark gold (with a) brown (tint)”.

In the case of red wines, the fundamental colour is red with hints (sub-tones) of purple or brown, again moderated by reference to its intensity. The description would thus read simply, for example, “dark red (with a) purple (tint)”; or “mid red (with a) brown (tint)”.

It is important to note again that any colour shade or intensity can be modified by a lack of clarity; especially in red wines. Wines are either clear (without haze; also known as bright) or have varying degrees of haze: the latter may be described as dull, cloudy, or even opaque (as in a fermenting white juice). The presence of a haze should be distinguished from that of a deposit, which may be crystalline, amorphous, or flaky, of varying colours.
Apart from colour and clarity, the appearance of viscosity of a wine is also considered. The ‘tears’ or ‘legs’ formed by the evaporation of ethanol on the inside of a glass above the wine are not a reliable guide to the concentration of alcohol in that wine. Their extent and form is affected by the glass itself, and the influence of various factors affecting their equilibrium with the vapour immediately above the wine’s surface. This is proven by the fact that their formation ceases a few minutes after a glass is covered with a piece of paper or plastic. A comprehensive review of the phenomenon is provided by Robinson (2006).

Aroma
Winemaking textbooks have frequently differentiated between the ‘primary’ aromas of wine and its ‘secondary’ bouquet. Undoubtedly wine aroma changes with age and characters that might be associated with fruit or fermentation diminish as bottle-age characters increase, but it is not unusual for experienced tasters to disagree on the supposed origin of a particular character, and thus disagree about the relative intensity of aroma or bouquet. Therefore, while it is often helpful for the taster to try and describe the ‘primary’ characters separately from those that might be ‘secondary’, it is not necessary, and possibly misleading, to formally differentiate between them.

The task of assessing a wine's aroma can be broken down into three elements: i) naming the aroma attributes that are perceived, ii) assessing the intensity of the different attributes, and iii) making a decision classifying the wine aroma according to one's memory of previous wines. In this way one may arrive at a final judgement of the quality of the wine's aroma. It is possible to decide on the quality level without attempting to put names to aromas, but it is considered important to undertake the naming exercise to assist in recalling the wine's characteristics and justifying an assessment.

The common Australian show system allocates a maximum of seven points to the aroma of the wine for the 20 point system or 35 points for the 100 point system. The weighting thus clearly places more importance on the palate, but it is not uncommon for professional tasters to argue over the relative importance of aroma and palate. The 'Old World' focus on regionality and the ability of a wine to age, compared to the 'New World' emphasis on varietal expression and intensity in youth, in which it is common to describe as fully as possible the aroma of a wine, also leads to a difference in relative importance, or weighting, as well as the specific tasting approach and terminology. This leads to some differences of opinion. Those who have adopted a highly descriptive approach, such as that advocated by the Wine Aroma Wheel (Noble et al. 1987), may be criticised by others who argue that the use of the terms is often arbitrary.

However, research has demonstrated that many of the original materials from which aroma and flavour terms have been derived contain the same aroma-active compounds as the particular grape varieties to which that term is applied. Examples include monoterpenes in flowers and citrus fruits and Riesling grapes and wine (Williams and Allen 1995); and methoxypyrazines in capsicums as well as wines made from Cabernet Sauvignon and Sauvignon Blanc (Williams and Allen 1995). Accordingly, the Aroma Wheel is considered a helpful tool, as it provides a useful set of descriptors that can be applied to describe most wine aromas in specific and definable terms. While not exhaustive, the structure of the wheel and the grouping of the terms make it readily applied.

Apart from the Wine Aroma Wheel, other tools such as lists of descriptive terms that are commonly-accepted as being typical of or common in specific varieties (Table 2) can also be useful for the evaluation of wine. It is important however to note that it is not assumed that varietal purity and intensity are necessarily associated with high quality.

Table 2. Commonly applied descriptors for wines for major grape varieties and styles

Grape variety/wine style	Flavour descriptors
General young white wine	Confectionery/lolly, banana, estery, citrus, American grape[1]
Riesling, Gewürztraminer, and Muscat family grapes	Floral: rose, talc, bath salts, muscat, musk, stewed apple, apricot Citrus: lime, lemon, grapefruit, orange peel, cooked lime Tropical: lychee, pineapple, passionfruit
Sauvignon Blanc, Semillon	Herbaceous: grassy, capsicum, asparagus, green bean, lantana, tomato leaf, asparagus, hay, straw, box tree/hedge, cat urine
	'Riper': quince, apple, citrus, grapefruit, apple, sweaty Tropical: passionfruit, pineapple, lychee
Chardonnay	Peach, fig, melon, apricot, citrus, quince, pear, apple, Tropical: passionfruit, lychee, pineapple
	Butterscotch, caramel, butter, caramel, cloves, nutmeg, smoky, honey, toast, nutty
Aged white wine	Honey, toast, caramel, butter, lime, kerosene, nutty
Shiraz	Spice, pepper, plum, raisin, chocolate, cherry, raspberry, violets, blackberry, liquorice, mint, cooked fruit
Cabernet Sauvignon, Merlot, Malbec, Cabernet Franc, Petit Verdot	Barely ripe: herbaceous, capsicum, asparagus, tomato vine, leafy, minty, tobacco, menthol, lantana, cooked/canned vegetables, vegetal, cooked corn
	Moderately ripe: Cassis, blackcurrant, *Ribena*®, plum, berry (raspberry, mulberry, blackberry), spice, violets
	Very ripe: jammy, *l'artre*[2]
Grenache, Mataro	Raspberry, spice: cinnamon, cloves, pepper Fruits: red berry, raspberry, cherry, plum
Pinot Noir	Fruits: strawberry, cherry, raspberry, violets, rhubarb, beetroot
	Herbal: bracken, tomato vine, leafy, sappy, lantana
	Spice: cinnamon, cloves
Oak related	Smoky, coconut, spicy (cloves, nutmeg), coffee, caramel, vanilla, toffee, charry
Lees contact/MLF derived/barrel fermentation	Butter, butterscotch, leesy, caramel, marzipan, *brioche*, Vegemite™, yeasty, doughy, cheesy
Aged red	Toasty, nutty, tobacco, leather, earthy, meaty
Fortified	Nutty, dried fruit, prune, blackberry, caramel, toffee, cold tea, molasses, raisin
Botrytis affected	Canned/dried apricot, honey, glacé fruits, citrus zest, pineapple, fungal, mushroom
Sparkling white	Caramel, struck flint, burnt match, yeast, vegemite, leesy, biscuit, bready, nutty, cashew, bruised apple
Chemical/faults	Oxidised (aldehyde, bruised apple, cardboard, wet wool, wet dog, varnish), reduced (rubber, struck match/flint, cabbage, rotten egg, sewage), earthy, musty/mouldy/fungal, BAND-AID®, medicinal, phenolic, smoky, chemical, plastic, chlorine-like, geranium, acetic, solvent, mousy

[1]'American grape' refers to the distinctive aroma and flavour of grape juice consumed in the United States which is typically produced from non-*Vinifera* varieties such as Concord. The aroma is generally very strong, and is known in other parts of the world as "foxy" or "something closer to animal fur than fruit" (Robinson 2006). In Australia, a wine described as "grapy" is more likely to have some muscat-like fruit, being from the family of *Vinifera* varieties with such aroma and flavour.
[2] French for chimney or hearth; a character reminiscent of cold ashes.

Palate
Obviously the most important part of the wine, the palate arguably deserves to be allocated more than 10 out of 20 points for quality for the 20 point system or 50 out of 100 points for the 100 point system. The assessment of the palate must take into account its multi-faceted nature:

- retronasally perceived flavours, type and intensity;
- true tastes (acidity, bitterness, sweetness, saltiness - umami is unlikely to be detected);
- textural elements which are principally felt, and may be described as tactile or mouth-feel sensations: astringency, heat, metallic sensation, viscosity and 'weight'; and
- the balance and persistence of sensations.

In contrast to the classical European approach of treating retronasal flavour and texture/structure as being roughly equally important, the general Australian focus has been primarily on flavour intensity and type. Thus, for example, oak types have often been chosen by Australian winemakers for the particular flavours that they provide: American oak for butter and coconut notes, French for spicy, nutty, smoky and toasty aromas. This focus on flavour is logical for certain wine styles, but ignores (again, using oak as an example), the textural effects which are contributed by the various oak types, and have long received greater attention from many 'Old World' winemakers. However, recently there has been a positive trend for Australian winemakers to place more emphasis on the textural/structural aspects of a wine's palate, while retaining the interest in optimising particular flavours. An attempt at defining a vocabulary for mouth-feel attributes (Gawel et al 2000) has been developed. Each term is defined and the 'mouth-feel wheel' provides a useful starting point for a panel to describe wine palate attributes. It is paralleled by a recent increase in interest in the savoury aspects of a wine's palate. While considered positive, this shift in emphasis should not come at the expense of the sweetness and intensity of fruit that is often considered to be a quality attribute of Australian wine. This is now vital to market acceptance, and thus export success.

Tasting with others is an extremely important aspect of achieving a level of judging skill. The process of tasting and assessing wine with others, firstly independently and in silence, followed by a discussion of the perceptions of the wines, allows the sharing of impressions and opinions and will improve the individual's ability to name and recall aromas in future. It will assist a group of tasters to produce similar quality judgements by aligning concepts of quality among the group.

The ability to concentrate, assimilate the sensory information and compare the impressions to recollections of previously assessed wines can be regarded as some of the most important requirements for the tasting process. Technical tasting ability is of little benefit without the mental discipline to competently assimilate, compare and judge the information provided by the senses. The difficulty of concentrating in a sustained manner should not be underestimated: when tasting large numbers of wines, apart from sensory adaptation, mental fatigue will play a large role in a person's ability to make repeated reasoned judgements. The act of such intense tasting requires careful thought to put names to sensory impressions and compare those impressions to recognised, remembered standards. A valid critical judgment requires a frame of reference, compiled with a good memory, against which the information is judged.

Rarely will the professional taster assess a single wine in exclusion. Many influences on the judgement of wine arise as a direct consequence of tasting several in succession, and are discussed in detail in Meilgaard et al. (1999) and Lawless and Heymann (1998).

Contrast or context is one of the more important effects. For example, a delicate wine presented among strongly flavoured wines will be considered differently—and almost certainly scored differently—compared to when the same wine is presented within a set of low flavour intensity wines. This can be rationalised as occurring due to two effects: physiological adaptation to a constant stimulus, and the propensity of humans to consider all impressions within a frame of reference. Lawless and Heymann (1998) give the example of a mild day in winter seeming warmer than a day of the same temperature in summer.

This change in frame of reference occurs because of our apparent need to adjust for the relative nature of objects being compared. Assessing a set of known young Riesling wines is carried out with the conceptual population of wines of this variety and style. If an aged Chardonnay is included in such a bracket it will be perceived to be more extreme than if presented in another, more similar, tasting context.

Tasters are prone to forming a temporary frame of reference which is a function of the wines being tasted. In such a situation a relatively poor wine tasted after a series of good wines will often be scored lower than if it were scored on its own. Conversely, a wine of average quality in a set of poor wines is likely to be rated higher.

The position of a wine in a set will also influence its assessment. Samples in the middle may be preferred over those at the ends, or in some circumstances the first wine(s) will receive a higher score than later wines. An obvious order or systematic arrangement may affect the results of a tasting if the taster detects a pattern in the samples e.g. if an unfined wine always precedes its fined partner, the taster will probably 'learn' the pattern over time, even if he or she is not informed of it.

During fault assessment tastings at the AWRI in which the order of wines has not been randomised, it has been observed that the first wine noted to have a TCA-like musty taint is often scored higher for this attribute than other tainted wines appearing later in the bracket. It has also been found untrained tasters frequently prefer the first sample assessed to subsequent samples.

Fatigue, degree of tiredness, hunger and other issues of emotional state and concentration will obviously affect responses between tastings and over the course of a single tasting. Generally it is recommended to carry out assessments in the morning, with no tasting held until at least half an hour has elapsed after eating or drinking.

The adaptation phenomenon also manifests itself in a carry-over effect where the first wine tasted will influence the second. This has been shown for both aroma and taste, where the common effect is for decreased perceived intensity of attributes, such as bitterness, in the second wine. This is particularly important in the case of the astringent sensation. When tasting a set of young red wines, the level of astringency can build over time unless there is a deliberate extended pause and a gap between samples, or the palate is refreshed through rinsing (or other intervention) between the tasting of successive wines. A recent study indicated that rinsing with a pectin solution between samples can reduce this carry-over effect for astringent samples (Colonna et al. 2004). A conscious decision to minimise the amount of retasting can also help.

The so-called 'halo' effect relates to a psychological predisposition of a person, if she or he has a high opinion of one aspect of a sample, to also judge highly other aspects of a wine's sensory properties. The fact that intensely coloured wines often score highly in overall quality (Somers and Evans 1974, Gishen et al. 2002) may be a manifestation of this fact. Thus having observed a strongly coloured wine, and perceived the aroma to be intense and complex, a taster might also be inclined to rate the palate of the wine highly, and possibly overlook a low level of bitterness or other problem. This can be manifested in an opposite effect, where negative impressions can lead to a diminished appreciation of the quality of other attributes.

A 'logical' psychological error is also common, with a bias involving a learnt relationship between one aspect of a wine and the usual consequence. For example, a brown tint in a white wine normally indicates either bottle-age or oxidative development. The taster may therefore be predisposed to note these aroma attributes than if they are deprived of this visual cue.

The tasting environment

As discussed above, it is necessary for the taster to consciously avoid stimuli that would otherwise lead to a loss of objectivity or sensitivity, or for a taster to prejudge a wine. Assessing a wine blind is considered best practice, unless there is some excellent reason for a taster to know the identity of the sample.

It is normally most productive, and very instructive, to taste and provide an assessment without any prior knowledge of the wine in the glass, and then retaste when the wine's identity is revealed.

Tasting when even slight cues or indications of the origin or identity of a wine is present means that the taster is prone to be biased in his/her judgement. Simple visual cues such as bottle shape or type of closure, or tasting in the presence of others who communicate their opinions during the tasting even in subtle ways such as frowning or expressions of disgust or enjoyment will very often predispose a taster to reconsider his or her initial impression. Other external knowledge such as disclosure of the purpose of the tasting can also bias responses, and it is a matter of judgement as to how much information to give to tasters about the wines they are to assess.

The tasting environment is important and basic control of lighting, temperature, ventilation, extraneous aromas, and minimising distractions (aural and visual) is critical. Recommendations are available to assist in developing appropriate rooms (International Standards Organisation 1988). While common in wineries, tasting at a bench close to or in a laboratory is not conducive to good concentration. This point is important: many experienced winemakers pride themselves on an ability to assess wines under poor conditions, and while this is laudable, distracting sounds, smells and interruptions will affect an assessment.
In formal sensory analysis situations, it is standard practice to taste in silence in isolated booths where it is not possible to observe fellow tasters, and it is surprising how much difference this can make to the level of concentration achieved.

The incident light source may have a significant impact on the appearance of the colour. Many show judges agree that certain judging venues have poor light, leading to an over-expression of a particular hue, such as green in white wines. For more detail on light sources and the practicalities of designing a tasting area for appearance assessment, please refer to Lawless and Heymann (1998). ISO standards (International Standards Organisation 1999) recommend fluorescent lights with a correlated colour temperature of 6500 K, colour rendering index 92 (minimum 90), also known as 'Daylight fluorescent', with uniform illuminance at the bench of between 1000 and 1500 lux. Most retailers of lighting can provide light sources (incandescent and fluorescent) of specific 'temperature', and winemakers should ensure that the light source in any dedicated tasting facility is appropriate.

Glasses

The influence of the glass on the aroma and taste of wine has been the subject of great debate in recent times, partly because of the marketing of a range of specialty glasses by some glass makers. While different size and shape glasses for various wine styles have been available for many years (for example, the tall, narrow flute for sparkling wine), with the advent of glasses purportedly made for specific varieties and wines from certain regions, wine tasters and consumers face a bewildering choice.

For routine critical sensory evaluation the so-called ISO tasting glass is acceptable. Also known in Australia as an 'XL5', the ISO glass (International Standards Organisation 1977) holds approximately 210 mL when brimful, with 30–50 mL being the standard tasting-sized serve. They are relatively cheap ($2–3 each), robust, and from better manufacturers, available in large quantities in very consistent shape, weight, and thickness and optical quality of the glass.

It is acknowledged, however, that glass size, shape and volume dramatically affect wine aroma (Fischer, 2000). This arises presumably through variation in the surface area of the wine in the glass, together with the entrainment of the volatile compounds in the air above the wine by the shape of the glass walls influencing the way in which the volatiles reach the nose. Thus the same wine smells different when assessed in different size and shape glasses, due to the influence of the physical attributes (size and shape) of the glass on the volatilisation and intensity of key aroma attributes. This effect was confirmed by Fischer (2000) in both red and white wines; and Delwiche and Pelchat (2002), who described it as subtle. In recent times several commentators (notably Halliday 2006) have suggested that larger, finer, glasses should be used in all wine show situations. Recently Australian wine shows have taken this advice and have adapted a larger glass size, typically the Riedel Magnum Overture, and for this reason we have adopted this glassware for AWAC.

Other effects attributed to the glass that may affect the taste of the wine, such as the supposed direction of the wine to specific parts of the mouth, are more tenuous and are unproven. Indeed, given the enormous variation in both the shape of human mouths and the way in which individuals sip from glasses, it is improbable that a specific glass is ‘best’ for a given wine style or variety.

In all cases, glasses must be very clean, free from dust, grease, detergent or lint. In hard water areas, the use of reverse osmosis (i.e. low ion content) rinse water is recommended. Often, after washing and drying in a commercial system, it is common for glasses to have a ‘dusty’ aroma, the cause of which is not known, and which may not be apparent in an empty glass but appears when wine is first poured into it. However, it generally dissipates after a short time, or after swirling of the wine. Black glasses are available which can be very valuable in eliminating colour biases during some evaluations.

Wine temperature

Both the ambient temperature and the temperature of the wine may affect the outcome of a tasting. As a bare minimum the wines being tasted should all be at the same temperature.

A wine may smell and taste quite different according to the temperature at which it is assessed, as the evaporation of different odour-active volatile substances will vary at different rates as temperatures change. In serving white or sparkling wines chilled, with small volumes poured for tasting, the wine will quickly increase to ambient temperature.

The difference between the aroma perceived by smelling a wine and the flavour perceived on the palate is partly due to a difference in the temperature. A wine served at 10°C will increase to 25°C if kept in the mouth for 10 seconds.

The tactile sensations observed when tasting also appear to differ over the temperature range 10–20 °C. The balance of sugar, acid, tannin, alcohol and carbon dioxide influences the choice of the optimum temperature to taste different wines.

Comparison of tasting methods—or how to taste up to eighty wines
To judge a large group of wines successfully requires the following attributes:

- determination
- concentration
- a system of approach—discipline
- a style/quality frame of reference
- decisiveness
- confidence in reproducibility of description and point
- a final check of quality—palate richness and length (depth).

Before judging a group of wines ensure that you understand as much as possible about them before you start:

- establish your frame of reference—however broad
- try to eliminate surprises
- have in your mind's eye a concept of what you are seeking
- be aware of the traps
- don't be afraid of mistakes
- spend time on quality.

Approaches to a bracket of wines
Some attendees may choose to use the course to make a comparison of two systems of approach to tasting, detailed below:

SYSTEM ONE:
Aroma ranking

Colour and condition
Aroma and bouquet
Rank
Nose (don't look at notes)
Taste
Compare 2nd impression to 1st

Rank
Re-rank the best
Re-point
Check back markers

Merits

SYSTEM TWO:
Isolated judgement

Colour and condition
Aroma and bouquet
Taste
Point
Re-do the 1st 6–10 wines
Pull out the best (>16 points)
Nose and taste the best
Rank the best
Re-point
Check back markers

Merits

1. assists memory
2. nose ranking easier
3. amplifies differences

Demerits

1. palate prejudicial
2. favours wine presence
3. favours aromatic wines

points)

4. amplifies small differences
5. slow: less time for quality

1. palate compensates
2. less prejudicial
3. rapid: allows time for quality

Demerits

1. subject to frame of reference drift
2. more prone to error
3. conservatism (narrow range of

Table wine quality—what is structure?

Presence

Quality table wine must have adequate presence.
Presence or dimension is not the major quality.

Vivacity (Freshness of aroma)

Even very old wines reflect native fruit and lack staleness.

Complexity and subtlety of bouquet

Quality table wine has complex aromatics. They must be teased apart into components, not dominated by a single aroma/bouquet factor.
Subtlety is a quality (wines of massive presence are rarely subtle).

Integrity

Consistency nose to palate. Aromatics are reflected in flavour on tasting.

Concentration

Fruit sweetness/richness.

Mouth-feel

Viscosity/astringency

- quality of tannin, not quantity
- total extract

Balance of taste and flavour

Acid to alcohol concentration and sugar

Length

Tasting traps

Preference drift

Change in frame of reference—first and last wines are particularly subject to this trap.

Awe factor

Dimension does not equate to quality. There is too much emphasis on quantity not quality—especially in big classes.

Aroma traps

Highly volatile aromas tend to capture preference, e.g., charry oak, vanilla, Muscat, terpenes, herbaceous, maceration carbonique.

Aroma shadow

Dimension shadow. Highly aromatic or big wines tend to overshadow adjacent complex or subtle wines.

Mouth kill

High alcohol, astringent tannin, bitterness faults, mousiness—carry-over to adjacent wines.

False fruit

The sugar, glycerol, sorbitol factor.

Added length

Oak factor.

Cellar palate

Recognition factor (Bordeaux/Champagne); familiarity factor.

Summary

Wine tasting is a difficult task, requiring concentration on the part of the taster and minimal distraction from their immediate environment. It is not an inherent ability of all individuals to taste well, but one that can be learnt through concerted effort. Everyone who wishes to improve and maintain their ability to taste must think about, and commit to memory, the attributes of each wine tasted. Individuals vary in their sensitivity and endurance and every good taster must be aware of, and respect, their individual limits. A good taster must also be able to communicate one's impressions clearly, precisely and reproducibly. One's influence on the market acceptance of wine may be considerable and the importance of one's role as a professional wine taster must therefore not be underestimated.

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6. Recognition of wine off-flavours and taints

It is essential that people who are called upon to assess the quality of wine must be able to accurately recognise the common sensory off-flavours and taints that occur in wines. One criticism levelled at the Australian Wine Show system and at Australian wine judges is that they pay too much attention to faults and not enough attention to the intrinsic quality of the wine being judged. The Australian wine industry, however, has set an objective of being able to produce wines free of off-flavours and taints, so that the flavours derived from fully ripened grapes, high quality oak and other winemaking procedures are not compromised.

An off-flavour or taint occurs when a contaminant is present in a wine (or any food product) at a concentration higher than its odour or taste threshold. The terms 'taint' and 'off flavour' have often been used interchangeably in the past. However, it is now common to use the term 'taint' to describe unacceptable flavours arising from external contamination of the product, whereas the term 'off-flavour' is used to describe an unacceptable flavour which develops within the food, through chemical or microbial action on food components.

An important aspect of taints and off-flavours is that there is a large range of sensitivity between individuals in their ability to detect some of these off-characters. Consequently, the lack of sensitivity of a winemaker to a particular taint or off-flavour can be the reason for difficulties encountered in preventing them and positively identifying the causes in some cases.

It is impossible to show all the winemaking off-flavours that are encountered in the many wine shows conducted in Australia each year and the taints that are sometimes observed in the assessment of wines. No attempt will be made to show wines that are grossly unbalanced, i.e. the acid content is too high for the level of fruit and alcohol sweetness in the wine, various faults due to over-extraction of the phenolic substances, or red wines made from overripe grapes and thus smell and taste like port.

The course will concentrate on the major sensory off-flavours that eliminate 5–15% of wines in the major Wine Shows and the taints that are encountered in wines submitted to the AWRI for investigation of sensory problems.

The major off-flavours encountered include:

• **Oxidation**	• Disulfides
• **Acetaldehyde**	• Dimethyl sulfide (DMS)
• **Volatile acidity**	• Sulfur dioxide (SO_2)
• **Ethyl acetate**	• Diacetyl
• **Mousiness**	• Geranium
• **Hydrogen sulfide**	• 4-Ethylphenol
• **Mercaptans**	• Indole

The major taints encountered include:

- Cork-type taints :
    - 2,4,6-Trichloroanisole (TCA)
    - 2,4,6-Tribromoanisole (TBA)
    - 2-Methoxy-3,5-dimethyl pyrazine (Fungal must)

- Geosmin

- Chlorophenols:
    - 2,4-Dichlorophenol
    - 2,6-Dichlorophenol
    - 2-Chloro-6-methylphenol or 6-chloro-*o*-cresol (6CC)

- Guaiacol

These taints and off-flavours are discussed below, including descriptions of their sensory properties, their origins, mechanisms of formation and their detection thresholds.

<u>Off-flavours</u>

Oxidation

Oxidation, particularly of white wines, was a common fault in Australian white wines 40 years ago when our table wine technology was reasonably primitive, compared to that of today. Oxidation is much less common today with the application of refrigeration, inert gas blanketing during the production and packaging operations and effective sulfur dioxide management. The oxidation flavour is due to a number of compounds, including a range of aldehydes.

Some wines are more sensitive to oxidation than others. Thus the white wines made from the 'floral' varieties such as Riesling are very prone to oxidation, whereas red wines can withstand significant oxidation during handling due to the higher content of phenolic compounds, which are natural antioxidants. The sensory characteristics of oxidation range from a dulling of the aroma, to 'cardboard', 'straw' and 'hay-like' aromas, to 'sherry-like' and 'maderised'. In extreme cases a 'wet wool', 'wet dog' or 'varnish-like' aroma may be evident. Of course for some wine styles, such as sherry, oxidation is deliberately encouraged.

Acetaldehyde

The sensory threshold for acetaldehyde ranges from 100-125 mg/L. Immediately after fermentation, table wines generally have acetaldehyde levels below 75 mg/L. However, above 125 mg/L acetaldehyde can impart odours described as over-ripe bruised apples, stuck ferment character or sherry and nut-like characters. Yeast can oxidise ethanol to acetaldehyde under oxidative conditions, therefore ullaged tanks can lead to surface yeast infection where acetaledehyde is produced (note that high levels of acetic acid and ethyl acetate may also be produced under these conditions). Ethanol represents the primary source of carbon in aerobic film-yeast growth.

Acetaldehyde levels increase as wines age due to chemical oxidation of ethanol. Acetaldehyde is also an intermediate in the bacterial formation of acetic acid and under low-oxygen conditions and/or alcohol levels greater than 10 % v/v, acetaldehyde tends to accumulate instead of being oxidised to acetic acid.

Apart from chemical and microbiological formation, winemaking practices can influence the level of acetaldehyde present in wine: addition of SO_2 during fermentation can increase the concentration of acetaldehyde, as can increases in pH and fermentation temperature.

Volatile acidity
Volatile acidity (VA) is a term that probably represents the wine industry's first measure of wine quality, although in a negative sense.

As a result the measure of volatile acidity is still prominent in the wine regulations of most countries, even though the components of volatile acidity represent no threat to health and the amount of volatile acidity tolerated will vary with the style of wine and the individual. The legal maximum content of volatile acidity in Australian wines, excluding SO_2 and expressed as acetic acid, is 1.5 g/L.

Volatile acidity is a measure of the low molecular weight, or steam-distillable, fatty acids in wine, with by far the major acid being acetic acid (>93%). However, other contributors to VA include carbonic acid (from carbon dioxide), sulfurous acid (from SO_2), as well as lactic, formic, butyric and propionic acids. Note that sorbic acid is also steam-distillable and should be taken into account if it has been added to wine (usually as potassium sorbate).

Given that acetic acid accounts for >93% of the measure of VA, it is not surprising that, sensorially, VA is generally perceived as the odour of vinegar. The aroma threshold for acetic acid in wine has been reported to be as low as 0.1–0.125 g/L, depending on the style of wine and the individual. However, the concentration at which the acid is regarded as detrimental is usually greater than 0.7 g/L. The VA is more easily detected if a small amount of ethyl acetate is also present, and in some cases ethyl acetate aroma can dominate.

During the alcoholic fermentation, yeast produce small amounts of acetic acid and the VA of a sound wine immediately after fermentation is usually in the range 0.1–0.4 g/L. However, native or wild yeasts such as *Hansenula* and *Kloeckera* can produce high concentrations of acetic acid before and during the early stages of fermentation. In addition, *Brettanomyces* can produce elevated levels of VA when grown under aerobic conditions. Some strains of *Saccharomyces* can also produce large amounts of acetic acid when placed under stress, i.e. during low or high temperature fermentations, during fermentation of high sugar musts, when available nitrogen is low or when the pH is low (i.e. <3.2). In addition, the AWRI has found that addition of vitamin mixtures to white grape juice fermentations increased the acetic acid concentration in the wines. The increase was highly variable and depended on the grape juice with the magnitude of the increase varying from 30% to 375%. Nicotinic acid and thiamine were the vitamins which most affected the increase in VA.

Increased levels of acetic acid in stored wines are usually attributable to growth of acetic acid bacteria (generally of the genus *Acetobacter*). These bacteria convert alcohol to acetic acid in the presence of oxygen. In fact until Pasteur's work in the mid-19th century a high proportion of wines spoiled through this mechanism before they could be consumed. Acetic acid bacteria are often isolated from red wines analysed at the AWRI, however, spoilage problems related to the growth of these bacteria only occur when the wines are exposed to air. In addition to lactic acid and carbon dioxide, heterolactic LAB may also produce elevated amounts of acetic acid when growing on glucose. Small amounts of acetic acid may also be produced during wine storage in new oak barrels due to hydrolysis of acetyl groups in the wood hemicellulose. In addition, it has been reported that acetic acid can result from the reaction of hydrogen peroxide, generated from coupled oxidation of wine phenolics, with ethanol to generate acetaldehyde, which is in turn oxidised to acetic acid.

Ethyl acetate

Various acetate esters, especially ethyl acetate, can contribute to the sensory perception of VA, as indicated above. Ethyl acetate is perceived as the odour of nail polish remover or airplane glue and has a reported sensory threshold of 12.3 mg/L. Ethyl acetate is the major ester produced by yeast and at low levels may contribute 'fruity' properties and add complexity to wine. The concentration of ethyl acetate ranges from about 30–60 mg/L in 'normal' wines, to about 150–200 mg/L in defective wines.

Factors that can influence ethyl acetate formation by yeasts include the yeast strain employed, temperature of fermentation, the amino nitrogen content of the juice and sulfur dioxide levels. As with acetic acid discussed above, native or wild yeasts such as *Hansenula* and *Kloeckera* can produce high concentrations of ethyl acetate before and during the early stages of fermentation. Ethyl acetate is also produced by acetic acid bacteria and is related to dissolved oxygen levels in the wine. It has been reported that growth of acetic acid bacteria under conditions of low oxygen tension can lead to higher levels of ethyl acetate.

Mousiness

Mousiness is an off-flavour reminiscent of caged mice or cracker biscuit, and in sensitive individuals renders the wine undrinkable. The off-flavour is generally perceived late on the palate or after the wine has been swallowed or expectorated and usually takes a few seconds to build. It tends to linger and leave a most obnoxious taste in the mouth for some time. If you move quickly to the next wine in a line-up, you may miss a mousy wine. Mousiness is rarely detected by sniffing because the compounds involved are not volatile at wine pH. Note that there is considerable variation in the sensitivity between individuals to the taint.

The compounds responsible for mousiness are the N-heterocyclic volatile bases 2-acetyltetrahydropyridine (ATHP), which is the main compound responsible, 2-ethyltrahydropyridine (ETHP) and 2-acetylpyrroline (APY). The sensory thresholds of these compounds in water and the ranges found in wine (Grbin et al 1996) are given in Table 3 below.

Table 3. Sensory thresholds of the compounds responsible for mousy off-flavour in water and the ranges found in wine.

Compound	Threshold in water (μg/L)	Range in wine (μg/L)
ATHP	1.6	4.8 – 106
ETHP	150	2.7 – 18.7
APY	0.1	trace – 7.8

The origin of mousy off-flavour is usually microbial, with most strains of lactic acid bacteria (LAB) being capable of producing the mousy character, particularly the heterofermentative species. These include *Lactobacillus hilgardii*, *Lactobacillus plantarum*, *Lactobacillus brevis*, and *Oenococcus oeni*. The yeast *Dekkera/Brettanomyces* are also capable of producing mousy compounds. In addition to microbial origin, empirical observation has shown that some wines develop mousy off-flavour when exposed to air or oxygen. The mechanism by which oxidation enhances mousy off-flavour is currently unknown. There is no satisfactory method to remove mousy off-flavour, which is more likely to occur in wines with low concentrations of SO_2 and low acidity.

The AWRI observed an increased incidence of mousy wines during the 1990s when winemakers moved to a lower sulfur dioxide regime for the production of red wines in particular. Many red wines and some full bodied white wines had no sulfur dioxide added until the completion of the malolactic fermentation. Such a regime demands a fastidious approach to cellar hygiene to prevent unwanted microbial growth and the possible formation of mousiness. The AWRI has recommended to winemakers that they should work at between 50 and 75 mg/L total sulfur dioxide (more for wines of high pH) for red wine production if they have any doubts about their cellar sanitation.

Hydrogen sulfide

Most winemakers will be familiar with the aroma of hydrogen sulfide (H_2S) or rotten egg gas. The threshold of detection of H_2S in wine is about 1–2 μg/L (parts per billion) and it has been reported that levels below the sensory threshold might play a role in wine complexity. The various forms of sulfur (e.g. sulfate, sulfite and sulfur-containing amino acids) are important for yeast biosynthesis. During alcoholic fermentation, yeast will excrete hydrogen sulfide into the fermenting juice when placed under stress, e.g. when the yeast starts to run out of nitrogen. Australian juices can be low in nitrogen and winemakers often supplement the juice with a soluble nitrogen source, such as diammonium phosphate.

Hydrogen sulfide can be produced in excess by yeast during fermentation due to the presence of elemental sulfur on grape skins (from sulfur sprays), inadequate levels of free α-amino nitrogen (FAN), added SO_2, a deficiency of B-complex vitamins (pantothenic acid or pyridoxine), unusually high levels of cysteine in the juice or a high concentration of metal ions. The production of H_2S can also be yeast strain dependent.

Winemakers minimize the formation of excess H_2S in white wines by either settling, centrifuging or filtering the must before fermentation, which removes high-density solids which might contain elemental sulfur. Some winemakers remove excess H_2S from red wines by aerating at the first racking, thus volatilising the H_2S. Aeration may also oxidise H_2S to elemental sulfur (S), however, the S precipitate must be removed (centrifugation or filtration) otherwise it might later reform H_2S, when conditions become favourable for reduction. Note that SO_2 can also convert H_2S to S. Many winemakers remove objectionable H_2S in red and white wines by fining with copper sulfate ($CuSO_4$). Copper sulfate reacts with H_2S to form copper sulfide, which is highly insoluble. However, careful laboratory trials should precede any $CuSO_4$ additions to bulk wine, as an instability can result if the copper concentration in the wine exceeds approximately 0.5 mg/L (even lower in some wines).

Mercaptan and disulfides

Mercaptan is a general term applied to the aroma of a range of compounds containing a terminal –SH moiety (thiols) and are variously described as cabbage, garlic, onion and rubber and many other colourful terms. Their presence in wine above the threshold is generally regarded as a defect; however, the odour of these sulfur compounds is important to many foods.

Thiols (mercaptans) are thought to be formed via chemical reaction between H_2S and wine components, possibly aldehydes and/or alcohols. However, it is known that methanethiol can be formed directly as a result of yeast metabolism. Both methanethiol (methyl mercaptan) and ethanethiol (ethyl mercaptan) may be rapidly oxidised to dimethyldisulfide (DMDS) and diethyldisulfide (DEDS), respectively. Therefore, if a wine containing methanethiol and ethanethiol is aerated to remove H_2S, the thiols may be oxidised to DMDS and DEDS, which do not react with copper. Removal of DMDS and DEDS requires the creation of reducing conditions, with the addition of ascorbic acid and SO_2, in order to reduce these compounds back to the reactive species (methanethiol and ethanethiol), which may then be removed by treatment with copper. Note that copper is not as effective at removing thiols as it is at removing H_2S, therefore, it is best to remove H_2S before it reacts further to form thiols. The sensory thresholds of some thiol and disulfide compounds, including some odour descriptors, are given in Table 4 below.

Table 4. The sensory thresholds and odour descriptors for some thiol and disulfide compounds.

Sulfur compound	Threshold (µg/L)	Odour description
Methanethiol	0.02-2	rotten eggs, cabbage
Ethanethiol	1.1	onion-like, rubber-like
Dimethyl disulfide	29	onions, cooked cabbage
Diethyl disulfide	4.3	burnt rubber, garlic

Dimethyl sulfide

Dimethyl sulfide (DMS) is one of the major compounds found in aged wines and is formed during the maturation of wine in the bottle, however, the mechanism of formation of DMS is not clearly known. At low concentrations it might contribute toward the body of aged white wines and has a 'vegy' or 'blackcurrant' character. At higher concentrations, the aroma of DMS is described as a fault and is described as 'asparagus', 'cooked corn', 'cooked tomato' or 'molasses'. The sensory threshold for DMS is between 30-60 µg/L. As dimethyl sulfide does not bind to copper it can be difficult to remove the aroma, however, removal might be possible by sparging with nitrogen or by using reverse osmosis.

Excess sulfur dioxide

Sulfur dioxide is one of two preservatives permitted for use in wine production in most winemaking countries—the other preservative is sorbic acid. Most countries set a legal maximum for the total sulfur dioxide content of wine. In Australia the maximum is 250 mg/L of total sulfur dioxide in products containing less than 35 g/L sugars, or 300 mg/L of total of sulfur dioxide for other products.

Winemakers add SO_2 to wine to minimise the effects of oxidation and also to inhibit microbiological activity. Winemakers refer to three categories of SO_2: free, bound and total. The free SO_2 is defined as the sum of the unreacted ionic forms, which are the molecular, bisulfite and sulfite forms. The bound SO_2 involves the portion of the bisulfite form which binds with particular wine components (to form bisulfite addition compounds) and which can be released by hydrolysis and/or by heat and distillation. Total SO_2 represents the sum of the free and bound fractions (Sneyd et al. 1993). The sulfite form ($SO_3^{=}$) of SO_2 in wine is the form that reacts with molecular oxygen, however, at wine pH this form is the least abundant. At wine pH the most abundant forms of SO_2 are the molecular (SO_2) and bisulfite (HSO_3^-) forms. Neither of these forms reacts with oxygen, however, molecular SO_2 does react quickly with hydrogen peroxide (H_2O_2). This reaction is responsible for the removal of H_2O_2 produced by the reaction of oxygen with polyphenols and the retardation of acetaldehyde formation and browning in wines. In addition, it is the molecular form that is responsible for the anti-microbial effect of SO_2 and is the form that we can smell when too much is added.

Sulfur dioxide has a pungent penetrating aroma which reacts strongly with receptors in the nose causing sneezing and often a choking sensation—a high content of free sulfur dioxide can be life threatening to a small proportion of asthmatics. A content of free sulfur dioxide up to 15 mg/L has no adverse sensory effect.

Diacetyl

Diacetyl (2,3-butane dione) is produced by both yeast and bacteria and low levels (1–4 mg/L) in wine usually add complexity (buttery or butterscotch characters), but high levels (>5 mg/L) might be considered objectionable, such that the wine might be regarded as defective.

The amount of diacetyl produced by yeasts is typically less than 1 mg/L, which is below the sensory threshold. Bacterial production of diacetyl during malolactic fermentation (MLF) represents the primary source of this compound and arises mainly from catabolism of citric acid. Under winemaking conditions, this generally occurs after all of the malic acid has been converted.

Formation of diacetyl is dependent on a number of factors, including the bacterial strain, the oxygen (O_2) tension of wine (increase in O_2 concentration favours the oxidation of α-acetolactate to yield diacetyl), the citric acid concentration and temperature.

Geranium off-odour

Geranium off-odour is attributable to the ether 2-ethoxyhexa-3,5-diene, which has an odour reminiscent of crushed geranium leaves. This compound has a reported threshold of 100 ng/L and its formation is the result of metabolism of sorbic acid by lactic acid bacteria (LAB). Sorbic acid (the other wine preservative mentioned earlier) is a short-chained unsaturated fatty acid and is widely used as a fungistat in sweet wines at bottling. Whilst sorbic acid is generally effective in the inhibition of *Saccharomyces* yeast, it has little activity toward *Dekkera*/*Brettanomyces* and *Zygosaccharomyces* yeast, or LAB or acetic acid bacteria.

At the relatively low pH of wine, some LAB are able to reduce sorbic acid to sorbyl alcohol which undergoes rearrangement to yield the alcohol 2,4-hexadiene-1-ol. This alcohol is able to react with the ethanol present in wine to produce 2-ethoxyhexa-3,5-diene, which imparts the ‘geranium tone’.

4-Ethylphenol

The volatile phenol 4-ethylphenol is one of the major spoilage compounds associated with the growth of *Dekkera*/*Brettanomyces* yeast in wine. This compound imparts a “Band aid®”, “medicinal” or “pharmaceutical” character to wine. A concentration of 425 µg/L of 4-ethylphenol has been reported to have a negative impact on the quality of many wines (Chatonnet et al 1992, 1993). Recent Australian sensory studies conducted at the AWRI have shown the aroma threshold in to be 368 µg/L in a neutral red wine (Figure 1) (Curtin et al. 2008).

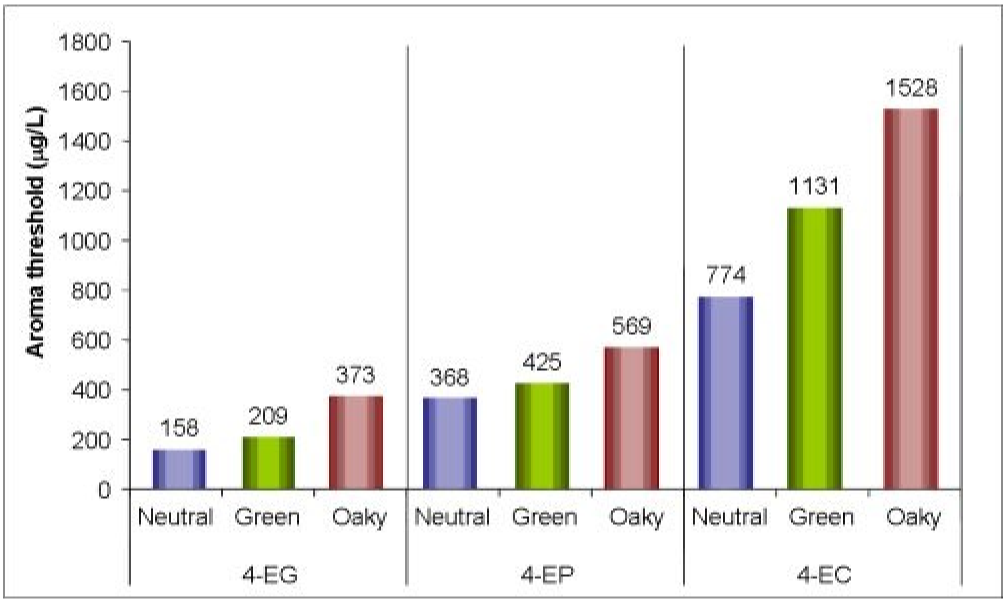

Figure 1. Aroma thresholds of 4-ethyl guaiacol (4-EG), 4-ethyl phenol (4-EP), and 4-ethyl catechol (4-EC) in three different Australian Cabernet Sauvignon wines.

Evidence from sensory assessments and analyses conducted at the AWRI suggest that the sensory perception threshold of 4-ethylphenol depends very much on the style and structure of the wine. For example, the aroma threshold of 4-ethylphenol in a full bodied red wine with intense methoxypyrazine green character was 425 µg/L and considerable oak influence increased the aroma threshold to 569 µg/L (Figure 1). That is, the extent to which the sensory properties of a wine may be affected by 4-ethylphenol will depend on the concentration and intensity of other wine components that may mask (e.g. volatile oak compounds), or accentuate (e.g. 4-ethylguaiacol), the aroma of 4-ethylphenol.

4-Ethylphenol is produced by the enzymatic decarboxylation and reduction of *p*-coumaric acid (an hydroxycinnamic acid), by *Dekkera/Brettanomyces* sp. yeast. The hydroxycinnamates are an important group of phenolic acids present naturally in grapes and must, including the derivatives of *p*-coumaric acid. *p*-coumaric acid is actually present as the ester of tartaric acid in grapes, however, postharvest hydrolysis, especially by pectin esterase, frees up the *p*-coumaric acid. The *p*-coumaric acid undergoes enzymatic decarboxylation to the corresponding vinylphenol due to the presence of cinnamate decarboxylase in yeast (not just *Dekkera/Brettanomyces* sp.). The last step, the conversion of 4-vinylphenol to 4-ethylphenol, is affected by the enzyme vinyl-phenol reductase, which is present in *Dekkera/Brettanomyces* but is totally absent from *Saccharomyces*.

Although some microorganisms, such as bacteria, may be capable of volatile phenol production under some conditions (e.g. model medium enriched with certain phenols), the amounts produced are very small compared to those produced by *Dekkera/Brettanomyces*. Therefore, it is generally accepted that *Dekkera/Brettanomyces* is the only microorganism responsible for the phenol off-odour in red wines, and 4-ethylphenol is now a recognised marker compound for presence of this yeast.

Other 'Brett' compounds

- **4-Ethylguaiacol**

4-ethylguaiacol is another major spoilage compound associated with the growth of *Dekkera/Brettanomyces* yeast in wine and has been described as having a 'clove', 'spicy' or 'smoky' aroma. It is derived in the same fashion as 4-ethylphenol but from a different precursor: ferulic acid. The aroma threshold for 4-ethylguaiacol is reported to be 110 µg/L, and was found to be 158 µg/L in Australian wine styles (Bramley et al. 2007). Whilst this concentration is much lower than for 4-ethylphenol, 4-ethylguaiacol is generally found in lower quantities in red wines, often 10 times less for Cabernet Sauvignon wines. Relative concentrations of 4-ethylphenol and 4-ethylguaiacol affect the overall perception of 'Brett' spoilage.

- **4-Ethylcatechol**

4-ethylcatechol is another spoilage compound reported to be associated with the growth of *Dekkera/Brettanomyces* yeast in wine and has been described as having a 'horsey' aroma. The aroma threshold for 4-ethylcatechol was found to be 774 µg/L in a neutral Australian red wine (Bramley et al. 2007). 4-Ethylcatechol is derived in same fashion as 4-ethylphenol but from a different precursor (caffeic acid). A survey of European wines found concentrations of 4-ethylcatechol similar to 4-ethylguaiacol (in Pinot and Cabernet wines).

Indole

The AWRI's tasting panel have used terms such as 'styrene', 'mothballs', 'reduced' and 'rubber/plastic' to describe the off-character produced by indole. Whilst indole has been implicated in the phenomenon known as untypical or atypical ageing (Zoecklein 1995), it has been the AWRI's experience that high levels are associated with stuck or sluggish fermentations and secondary fermentations in sparkling winemaking.

Indole is formed by yeasts and is related to the metabolism of the amino acid tryptophan. The ability of wine yeast to transform tryptophan to indole during fermentation was recently investigated at the AWRI (Arevalo-Villena et al. 2010). All ten yeast strains investigated were able to produce indole in the presence of tryptophan. The indole concentration peaked when approximately half of the sugar had been consumed, and then decreased in concentration through catabolic metabolism as the fermentations continued. This study concluded that the metabolism of tryptophan and indole might be altered during sluggish fermentations, causing the accumulation of indole. Given that indole off-odour has also been observed after the secondary fermentation during sparkling wine production, yeast stress might also be a factor associated with the production of indole.

The AWRI determined the aroma detection threshold of indole in a neutral, dry white wine to be 23 µg/L (Coulter et al. 2008; Capone et al. 2010). A preliminary survey of a number of commercially available Australian wines was also conducted and the indole concentration was found to range from approximately 1 µg/L to 10 µg/L, with a mean concentration of approximately 5 µg/L. Investigations at the AWRI have shown the concentration of indole in wines affected by this off-flavour to range from approximately 30 µg/L to 500 µg/L.

Taints

Cork-type taints

- **2,4,6-Trichloroanisole**

The main compound responsible for cork taint is 2,4,6-trichloroanisole or TCA. It is one of the most odour intense compounds known and has a distinct musty, mouldy aroma (Amon & Simpson 1989). One study determined the aroma threshold of TCA in a Pinot Noir wine as 1.4 ng/L (Duerr 1985), however, the aroma threshold may be lower in dry, white wines, or higher in full-bodied red wines. Prescott et al. (2005) reported that the consumer rejection threshold for TCA was 3.1 ng/L whilst the consumer detection threhsold was 2.1 ng/L. Some tasters at the AWRI are able to detect TCA present in wines at less than 1 ng/L. The AWRI found that the presence of TCA at a concentration as low as 1 ng/L suppressed the ratings for overall aroma intensity and of positive fruit-derived characters of a particular Semillon wine during sensory evaluation.

The AWRI has found several other odour-intense compounds present in wines that have musty, earthy or mouldy aromas, and these are shown in Table 3.

Table 3. Odour-intense compounds, present in wines, imparting a musty, earthy or mouldy aromas

Compound	Threshold	Odour description
2-methylisoborneol	30 ng/L	camphor-like, earthy
geosmin	25 ng/L	earthy, muddy
1-octen-3-ol	20 µg/L	mushroom, metallic
1-octen-3-one	20 ng/L	mushroom, metallic
2-methoxy-3,5-dimethylpyrazine	2.1 ng/L	“fungal must”

The AWRI has also shown that TCA can be formed in oak, and as a result wines can have a cork taint without any contact with cork.

TCA is generally formed as a result of moulds growing on cork and coming into contact with trichlorophenol. Trichlorophenol and related chlorophenols are excellent biocides and have been and appear to be still used by industry as general disinfectants. Some moulds can detoxify the trichlorophenol and related chlorophenols by inserting a methyl group on the benzene ring to form TCA and related anisoles. The chlorophenols can arise in the cork by aerial contamination or by the chlorination of phenol which is a natural component of cork.

- **2,4,6-Tribromoanisole (TBA)**

Another compound responsible for cork taint is 2,4,6-tribromoanisole. It behaves similarly to TCA and has a similar distinct musty, mouldy aroma. Chatonnet et al. (2004) reported that the aroma of TBA was perceptible at a concentration of 4 ng/L in wine, and that it could be detected at lower concentrations by tasting. A range of exceedingly low detection thresholds in water have been reported including 0.008 ng/L (Saxby et al. 1992), 0.02 ng/L (Whitfield et al. 1997) and 0.03 ng/L (Malleret and Bruchet 2001).

Chatonnet et al. (2004) indicated that TBA can be formed in wineries by the microbial breakdown of 2,4,6-tribromophenol (TBP), which is widely used as a flame retardant and as a fungicide or wood preservative, and can also be formed in wastewater. TBA has also been detected in barrels, plastics (including synthetic closures), natural corks, wood structures including walls, floors and ceilings, and in the atmosphere of wineries. Additionally TBA is also known to be readily absorbed by plastic materials and corks.

- **2-Methoxy-3,5-dimethyl pyrazine (fungal must)**

2-Methoxy-3,5-dimethyl pyrazine or 'fungal must' (FM) is possibly the second most important form of cork taint after TCA. The threshold of FM in a neutral white wine was determined to be 2.1 ng/L, which is comparable to that of TCA.

FM has been described by Mottram et al. (1984) to be responsible for an obnoxious odour present in certain machine cutting emulsions used in engineering workshops. It was described as 'musty', 'foul drains', or 'sour dishcloths'. It has also been identified in coffee where it was described as having an earthy aroma. It was important to both raw and roasted coffee and produced an intense aroma with an aroma threshold of 0.4 ng/L in water.

Mottram et al. (1984) concluded that FM was likely to be a relatively common cause of off-odour in the environment. However, there has been no further report of it as a cause of off-odour in the published literature over the following 20 years, and only one report of its occurrence in a food product.

Chlorophenols

- **2,4-dichlorophenol**

2,4-dichlorophenol (2,4-DCP) is one of a number of chlorophenol compounds. There are several types of chlorophenols that include mono, di, tri, tetra and pentachlorophenols and mixtures of these classes of chlorophenols have been widely used as biocides and are now considered general environmental contaminants. The aroma detection threshold of 2,4 DCP in wine was determined at the AWRI to be greater than 896 ng/L. Chlorophenols are generally described as contributing toward the odours of ‘plastic’, ‘paint’, ‘medicinal’ or ‘phenolic’.

Mono-, di- and trichlorophenols can easily be generated by the chemical chlorination of phenol. Chlorine-based sterilising agents, such as hypochlorite solutions, can react with traces of phenol present in materials such as plastic or fibreglass tanks or linings, phenolic-based resins, paints and fittings. Chlorophenols are also generated when wood is treated with hypochlorite solutions and are formed in the bleaching of wood pulp for paper manufacture. Sometimes wooden pallets loaded with cartons are stored near processing areas where disinfectants containing available chlorine are used. In situations such as this, chlorophenols can be generated in the cartons or pallets if they contact chlorine. It is interesting to note that Saxby (1992) indicates that the presence of dichlorophenols might indicate spillage of phenolic herbicides on the wooden floors of shipping containers. In addition, products such as fibreboard and paper made from recycled materials can often contain relatively high levels of chlorophenols, which can then contaminate food products or processing aids packaged in the fibreboard or paper (Mottram 1984).

- **2,6-Dichlorophenol**

2,6-Dichlorophenol (2,6-DCP) is one of the more potent and sensorily important chlorophenol compounds and tasters use the typical chlorophenol aroma descriptors to describe 2,6-DCP, such as ‘plastic’, ‘paint’, ‘medicinal’, ‘chlorine’ and ‘phenolic’. Tasters have also use terms such as ‘hot, burning finish’, ‘bitter, metallic finish’ and ‘chemical aftertaste’ to describe the palate effects of 2,6-DCP.

The AWRI determined the aroma detection threshold of 2,6-DCP in a neutral white wine to be 32 ng/L, which is considerably lower than the thresholds (22 µg/L and 200 µg/L) determined for this compound in water by Young et al. (1996) and Dietz and Traud (1978), respectively. Concentrations of 2,6-DCP up to 236 ng/L have been found in tainted wines investigated at the AWRI.

- **2-Chloro-6-methylphenol or 6-chloro-o-cresol (6CC)**

6CC has been reported to be responsible for taints in chicken meat (Patterson 1972), biscuits (Griffiths and Land 1973), soft drinks (Whitfield 1983) and more recently in wine from the use of contaminated yeast hulls. Contamination of products or processing aids with 6CC has been reported to be the result of exposure to airborne contaminants due to proximity to agrichemical plants or due to the use of disinfectants containing 6CC in the food processing plant. The AWRI determined the aroma detection threshold of 6CC in a neutral, dry white wine to be 70 ng/L.

Geosmin

Geosmin has an ‘earthy’, ‘musty’, ‘muddy’ aroma with a sensory threshold of 25 ng/L. Both geosmin and 2-methylisoborneol are primarily known as metabolites of soil bacteria and algae, such as actinomycetes or cyanobacteria, and are responsible for off-flavours in town water supplies and fish (Young et al 1996). However, several moulds amongst those isolated from corks are also capable of their biosynthesis. Geosmin has also been reported as a metabolite of *Botrytis cinerea*. Although geosmin may be present in wines, a relatively high concentration might be tolerated.

Guaiacol

Guaiacol is a component of smoke and has been described as 'smoky', 'phenolic' and 'medicinal'. The AWRI recently determined the aroma threshold of guaiacol to be 23 µg/L and the taste threshold to be 27 µg/L in a red wine.
Guaiacol is formed during the barrel toasting process and can then be extracted into wine at a typical concentration of 10–40 µg/L. Guaiacol has been reported to be a possible component of cork taint, as it is the primary off-flavour compound in faulty corkwood affected by a yellow discolouration. Guaiacol is formed by soil bacteria such as *Streptomyces* sp. (which grow on lignin in the corkwood) and other microflora including some moulds. However, cork producers are aware of this and normally cut off any affected sections of the cork slabs. Although guaiacol is present in corkwood, the quantities formed by the degradation of lignin under normal processing conditions for wine corks would be insufficient to cause a taint in cork. Therefore, guaiacol is not a significant cause of cork taint in Australia. Guaiacol is often below its flavour threshold concentration and influences wine aroma by acting in combination with other components. (Synergism – response to several components is greater than the sum of the individual contributions).

Bushfires and controlled burning of bushland can impart a smoke taint to grapes in nearby vineyards. Smoke taint from bushfires has been found to impart a back-palate 'excessively drying' character to affected wines and a lingering retro-nasal 'ash' character, which appeared to be more pronounced in smoke-affected samples than in juices or wines spiked with similar concentrations of guaiacol.

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7. Explanation of statistical results

Reliability	A measure of scoring consistency, or the ability of a judge to reproduce results on different occasions. A value close to +1 indicates good consistency, a score close to 0 indicates a random scoring pattern, and a score close to –1 indicates that the score given on one occasion was the opposite of that given on another. In the context of the scores given, **the higher the number, the better.**
Significance	The statistical significance of your reliability measure. For the purposes of this course, interpret this column as the greater the number of stars, the more confident you can be that the pattern of scoring given by you was not simply a chance effect. That is, you consistently perceived quality variations between the wines and scored them accordingly.
Discrimination	The degree to which the wines were separated on the basis of quality. For example, if the mean scores given to some wines are much greater or smaller than others, the discrimination will be high—and if all means are equal, the discrimination will be zero. Given that in this exercise the wines were selected to represent a wide range of qualities, **the higher the number, the better,** with greater than 3 being desirable.
AAD	An alternative and perhaps more straightforward measure of consistency. It is the average difference between scores given to wines on repeat tastings. For example, an AAD of 1 means that, on average, a person scored the repeat wines differently in either direction by 1 point. Therefore, **the lower the score the better,** with less than 1.5 being desirable.
Stability	Here we counted up the number of times you increased your score on the repeat tasting, how many times you decreased your score on the repeat tasting, and how many times you scored them exactly the same. A stability measure of +4 means that you shifted up four more times than you either shifted down or scored them the same. So it is a simple measure of your propensity to systematically score higher or lower on the second tasting relative to the first. Therefore a stability score of 0 is ideal, with either small positive or negative scores being better than large positive or negative values.