Tannin Sensory Perception and its Relationship to Other Flavour Contributors

BRIAN WALSH
S. Smith & Son Pty Ltd, Yalumba Winery, Angaston, SA

This paper explores the sensory nature of tannins and their interaction with other compounds in wine and how that interaction may alter the impact of the tannins and vice versa.

To provide a convenient reference point near the start of the modern Australian wine industry, the following quotation from Walter James’ 1959 publication A Word Book on Wine is proffered:

‘Tannin is found in the skins, stalks and pips of the grape and is added in powder form when deficient. It is mainly responsible for the dry finish of a good wine and its agreeable grip on the palate, seen to perfection in good French clarets, though in this instance a good deal of it comes from the new oak casks in which the wine spends its first year.’

The principle compounds discussed are: alcohol, acid, fruit and oak. The psychological effects of tannins and phenolics on sensory perception are not explored except to say they are real, particularly the effect of phenols on colour, and how that influences our ultimate perception of a given wine.

The principal sensory contributions of tannins are astringency and bitterness. Although bitterness is elicited by a wide range of chemical compounds, the primary source of bitterness in wine is generally thought to be phenolic compounds (Fischer and Noble 1994). A ll of the phenolic compounds in wine which elicit bitterness also elicit astringency (A mold et al. 1980).

It is appropriate to revisit the sensory understanding of astringency and bitterness. The four primary tastes generally register in sequence from the front to rear of the tongue, viz. sweet, salty, acid and bitter.

The taste buds are located in papillae along the length and breadth of the tongue. The papillae are respectively known as fungiform, filiform, foliate and circumvallate. Bitterness is registered by the circumvallate papillae only and is generally regarded as being perceived only after swallowing in the case of drinking or as an aftertaste in the case of tasting.

Therefore, when discussing bitterness consideration should be made in terms of aftertaste (and the length and persistence). The perception of bitterness (or sourness) appears to be no different whether swallowing of samples or expectorating of same.

The intensity of both astringency and bitterness have been shown to increase under the normal tasting conditions of rapid and repeated ingestion (Guinard et al. 1986). A stringency intensity increased when red wine was sipped (and swallowed) at 20 second intervals, but not at 40 second intervals (Fischer and Noble 1994).

When tasting a wine containing all four so-called primary tastes of sweet, acid, salty and bitter, as well as the myriad of wine flavours, the tastes are perceived progressively, not simultaneously—initially, at least. Depending on the persistence of the particular tastes and the length of time in the mouth, they may all eventually be tasted contemporaneously. This can complicate the search for balance and harmony in a wine as the taste and tactile sensations can be happening:

• on a different time-frame, and
• at a different place in the mouth.

The need to use the maximum surface area in the mouth is self-evident. Astringency is not a taste, but can be considered to be the dry and puckery sensation and is chemically defined as the ability to precipitate proteins (Bate-Smith 1954). It is not confined to a particular region of the mouth or tongue, but is perceived as a diffuse stimulus which requires appreciable time for development (Kallithraka et al. 1996).

The physiology of astringency is not well defined. Emile Peynaud (1996) hypothesised three causes of astringency:

• The coagulation of the mucin in the saliva whose glycoproteins are rendered insoluble by astringent substances. The mixture of red wine and saliva precipitates the coloured filaments which can be seen in the taster’s spitoon.
• The sensation of dryness may also be due to the salivary gland canals being constricted so that their saliva secretion is stopped, particularly in the case of the scattered glands which irrigate the mucous membranes.
• Astringents fix themselves to mucous tissues and these are hardened in consequence by loss of water and reduction in permeability. This final reaction, while making due allowance, is similar to the tanning process. Kallithraka et al. (1997) proposed that astringency should be considered as being made up of three components—

Figure 1. Distribution of circumvallate, filiform, foliate and fungiform papillae on the human tongue. Source: Netter (1959).
mouth drying, mouth roughening and mouth puckering. These astringent sensations are removed from the mouth with salivation which helps clear the mouth of phenols and/or provides new proteins to replace the precipitated ones (Joslyn and Goldstein 1964).

When tasting wine the winemaker is taught that astringency is more desirable than bitterness. As wine ages the more bitter monomers and dimers polymerise to less bitter and more astringent trimers and higher polymers. Ultimately, further polymerisation of the flavonoids will result in reduced astringency as the large, insoluble polymers precipitate.

The rate at which wine consumers are currently devouring young Australian reds provokes the thought that we are teaching our drinkers to become acclimatised to and more accepting of bitterness and astringency.

The origin of the tannins will have a bearing on the flavour contribution. Tannin in wine can come from:
- the skins, seeds and stalks of grape;
- oak maturation;
- added tannins.

In the case added tannin, the origin of the tannin is varied and includes:
- chestnut trees;
- oak galls;
- oak trees;
- other exotic woods, including acacia;
- grapes and grape seeds.

If adding tannins care should be taken as the bitterness can vary depending on the source. Nicolas Vivas (1997) found bitterness perception of tannin from chestnut tree and oak galls at 48 and 35 mg/litre respectively compared to 100 mg/litre for oak tannin.

The winemaker needs to be sure that, for whatever reason a tannin addition is made, the wine in question has the capacity to absorb the bitterness in a positive way—tannin additions do not necessarily make up for natural deficiencies.

The natural tannins of wine, from the skins, seeds and stalks are flavonoids or condensed tannins. The exogenous tannins from oak maturation or commercial preparations are non-flavonoid or hydrolysed tannins.

Emile Peynaud (1996) recommends the following simple experiment to reinforce in the winemaker's mind the significance of the balance between and the contribution of alcohol, acid and tannins:

A quantity of well-balanced red wine is distilled to separate the alcohol. After distillation, both the alcohol and the residue are separately brought back to their original volume with water. The tasting of the two components is a striking reminder of the differing contribution of alcohol and tannins. The distillate is sweet, perfumed, vinous, but rather bland. The residue is green, hard and bitter. Each needs the other. It clarifies the concept that the wine as a whole was only agreeable because the acidity and bitterness were balanced by the alcohol.

This introduces the first simple state of balance, namely: Sweetness (in this case of alcohol) must balance the sum of the acidic and bitter flavours:

- The less tannic a red wine the more acidity it can support.
- The richer a red wine is in tannins the lower should be its acidity.

Those winemakers who have dabbled in the world of reduced alcohol wines will know that if the sweetness is not provided by alcohol, significant quantities of sugar are needed to compensate.

Emile Peynaud and Jean Riberau-Gayon (1996) in an attempt to develop a quantified model to discuss this developed a 'Suppleness Index', where

\[
\text{Suppleness} = \text{Alcohol} - (\text{Acidity} + \text{Tannin}).
\]

Units were:
- Alcohol \% alc by volume.
- Acidity grams/litre TA, expressed as sulphuric acid.
- Tannin grams/litre [An index of total polyphenols where 1 g/l tannin = index of 20].

To further explore the mouthfeel relationship between alcohol, acid and tannin and to test run the 'Suppleness Index' a tasting was set up of the following diverse range of red wine styles. The terms light, medium and full-bodied were assigned to the Australian wines only as they were from our stable.

<table>
<thead>
<tr>
<th>Wine Type</th>
<th>Year</th>
<th>Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverland Shiraz, 1995</td>
<td></td>
<td>Light</td>
</tr>
<tr>
<td>Riverland Shiraz, 1996</td>
<td></td>
<td>Light</td>
</tr>
<tr>
<td>Burgundy, Appelation Mercurey, 1993</td>
<td></td>
<td>Light/medium</td>
</tr>
<tr>
<td>Eden Valley Pinot Noir, 1996</td>
<td></td>
<td>Light/medium</td>
</tr>
<tr>
<td>Barossa Cabernet Sauvignon/Merlot, 1995</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Barossa Shiraz, 1994</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Bordeaux, 5th Growth Pauillac, 1985</td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td>Coonawarra Cabernet Sauvignon, 1991</td>
<td></td>
<td>Full-bodied</td>
</tr>
<tr>
<td>Coonawarra Cabernet Sauvignon, 1995</td>
<td></td>
<td>Full-bodied</td>
</tr>
<tr>
<td>Barossa Shiraz, 1990</td>
<td></td>
<td>Full-bodied</td>
</tr>
<tr>
<td>Barossa Shiraz, 1995</td>
<td></td>
<td>Full-bodied</td>
</tr>
</tbody>
</table>

The tasting

Wines were presented in black tasting glasses.

Nine tasters were asked to comment on the wines' balance on the palate by either a no, yes or a qualified yes. If no or qualified they were further asked to comment on what attribute was providing the lack of balance. The qualified yes was intended to cater for a comment like;

\[
\text{Suppleness} = \text{Alcohol} - (\text{Acidity} + \text{Tannin}).
\]

To further explore the mouthfeel relationship between alcohol, acid and tannin and to test run the 'Suppleness Index' a tasting was set up of the following diverse range of red wine styles. The terms light, medium and full-bodied were assigned to the Australian wines only as they were from our stable.

Riverland Shiraz, 1995, light-bodied
Riverland Shiraz, 1996, light-bodied
Burgundy, Appelation Mercurey, 1993
Eden Valley Pinot Noir, 1996, light/medium-bodied
Barossa Cabernet Sauvignon/Merlot, 1995, medium-bodied
Barossa Shiraz, 1994, medium-bodied
Bordeaux, 5th Growth Pauillac, 1985
Coonawarra Cabernet Sauvignon, 1991, full-bodied
Coonawarra Cabernet Sauvignon, 1995, full-bodied
Barossa Shiraz, 1990, full-bodied
Barossa Shiraz, 1995, full-bodied

The tasting

Wines were presented in black tasting glasses.

Nine tasters were asked to comment on the wines' balance on the palate by either a no, yes or a qualified yes. If no or qualified they were further asked to comment on what attribute was providing the lack of balance. The qualified yes was intended to cater for a comment like;
The wine was very good with great weight and structure, but I found the tannin a little dominant at the moment of tasting.

Results and discussion
No correlation between alcohol, acid and tannins was found on the degree of balance or suppleness of the wines. Riberau-Gayon and Peynaud's work, however, was conducted on relatively young wine and they made the point that this should be so. The exercise was worthwhile, however, as it provided a particular focus on tannins and balance that we hitherto had not studied formally.

The following conclusions were made:

- The measurement of alcohol, acid and tannin is too simplistic a method of assessing balance in wine.
- The realities that different taster's tolerance to and acceptance of astringency and bitterness was reinforced.
- The contribution of oak maturation both on the oak flavour and the softening (sweetening?) affect on the wine is significant.
- The fruit intensity, power and richness on the palate is the ingredient which seems most needed to provide balance in wines of high phenolic content.
- There is a degree of uncertainty in the source of the necessary 'sweetness' to balance high tannin wines. Is it fruit sweetness, oak sweetness or alcohol sweetness? Most likely all, but how to tell?
- The missing equipment in the experiment was the fruit-meter, but most of the tasters had their own. Further, the glycosyl-glucose assay may well provide the key. (Williams and Francis 1996) suggesting that quantifying total glycosides gives an indication of juice 'richness'.

Other observations and those from the literature include:

- Fischer and Noble (1994) showed that an increase in alcohol from 11% to 14% produced a 41% increase in bitterness. Both maximum intensity and total persistence of bitterness increased as the ethanol level was raised. Given that, at the premium end of the red wine spectrum in Australia, alcohol levels of 11% are uncommon and that the majority of wines would fall between 13% and 14% then a 1% increase in alcohol at the 13% level is likely to be less significant.
- Sugar delays the effect of bitterness and astringency. The more sugar, the longer the delay.
- Generally, there are not significant levels of residual sugar in red wines, although with some of the higher alcohol reds being made currently, the presence of residual sugar may become more common.
- Expedition liqueuring of sparkling red wine is, of course, quite common. This is done to compensate for the enhanced tannin and acid sensation brought about by the high levels of dissolved CO₂.
- Conversely, bitterness adds savour to a sweet solution.
- Aidity has been reported to temporarily mask bitterness, but then accentuates its perception on the aftertaste.
- Although sourness is the predominant sensation of organic acids, dryness or astringency of acids has also been reported (Lee and Lawless 1991).
- Bitterness and astringency reinforce acidity, making it seem more excessive.
- Kallithraka et al. (1997) found no differences between malic and lactic acid on the intensity or duration of astringency. Intensity and duration, however, both increased with decreasing pH.
- Singleton and Noble (1976) report that flavonoids have no significant odour in the pure state. In wine the odorous phenols would be expected in the non-flavonoid fraction. Many phenols not found in wine are said to display pungent or burning sensations.
- It is a fact that exogenous tannins have an odour often described as woody or bark-like.
- Experienced winetasters use phenolic as a descriptor for both aroma and palate.
- Similarly, tasters have been known to describe a nose as bitter as an intuitive sense of expected flavour. This could be the pungent aroma of excessive phenolics.
- Although the content of distillable phenols in wine is low, it is higher in reds than in whites and higher again in reds of extended pomace maceration (Dziakhau et al. 1975).
- Perhaps the 'seed-oil' character of such macerated wines is partly volatile phenols.
- It has also been reported that concentrations of volatile phenols have increased with bottle age in both white and red wine——could some of the descriptors including spicy, tarry, warm, earthy, toffee and the ubiquitous bottle-aged be tannins?
- The role of oak with tannins is both subtle and complex.
- Additional phenolic material is imparted to wines matured in oak barrels (Noble 1990). This is almost entirely non-flavonoid. The phenols of oak extract include elagittannins as major components.
- However, Singleton and Noble (1976) suggest that it is very probable that the group of volatile phenols in wine, especially those aged in oak cooperage, can contribute detectable flavour to wines. While the content (of those phenols) is low and may not reach threshold for any one component in wine, the flavours of many are similarly described as spicy, smoky, phenolic, medicinal, etc and should be additive in flavour. Some of those descriptors are the same as might be used for describing oak flavours.
- Oak has a more significant impact on bitterness and astringency by the slow rate of oxidation occurring. The increase in polymerisation will result in a reduction of bitterness and astringency as the polymers precipitate (Haslam 1980).
- Both astringency and bitterness in wine can be reduced by fining with a proteinaceous agent such as egg white, gelatine or casein. Polyvinylpolypyrrolidone can be used to remove bitterness. Because of the delicate state of balance care must always be taken that in removing one problem, that one is not exposing another. This is particularly so with phenolics.

The contribution of the fruit, both in its primary and secondary flavours and in the natural level of phenolics is profound.
Other speakers will be discussing vinification techniques and fruit tannins, but a small comment on grape influence is warranted.

- It is well known that the level of total phenolics in grapes is a function of the grape variety.
- Grapes grown from cooler regions tend to have a higher phenolic content at harvest.
- With normal destemming of red grapes, most of the contribution of tannins is from seeds and skins, approximately 65% and 35% respectively.
- Without destemming, the stalks can change the approximate ratio to seeds 45%, skins 20% and stalks 35%.
- The flavour of stalk tannins, seed tannins and skins tannins is different.
- The degree of efficiency of the destemming process can have an impact on the type and flavour of the tannins.
- Ripe fruit, ripe tannins and high alcohol red wine is currently the fashion. Better viticultural practices are eliminating the likelihood of green, acidic and vegetal tannins.
- According to (Singleton and Esau 1969) the phenolic content of grapes increases throughout the ripening season until maturity.
- Other work points to a loss of astringency associated with fruit ripening.
- Possibly that elusive point of suppleness which winemakers search for is tied to that point of plateau, where fruit reaches sugar maturity and the suppleness is enhanced by a buildup of glycosides and a slight reduction in tannins.
- We need to be mindful, however, that a wine does not have to contain greater than 13.5% alc by volume to achieve balance or greatness.
- The creep in alcohol levels past 14% towards 15% and beyond may bring other problems of balance and the resultant wines are unlikely to be subtle.

When we talk about tannin we are talking about mouthfeel, but as has been shown the tannin interactions are multiple and complex. The fact that tannins are in a state of polymerisation gives a moving target. Tannin plays an integral role in:

- balance and harmony,
- richness and suppleness,
- freshness and longevity,
- colour and development, and
- quality and persistence.

The greatness of red wine is generally judged by its ability to age gracefully for at least a decade or two. To live up to that expectation a wine must have a balance between alcohol, acid and tannin as well as an abundance of fruit and (if desired) a contribution from oak. Phenolics hold a key to this greatness.

References

TANNIN SENSORY PERCEPTION AND ITS RELATIONSHIP TO OTHER FLAVOUR CONTRIBUTORS 27

ASVO Seminar • Phenolics and Extraction