Wine and oral lubrication: how mouthfeel is influenced by wine components

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Abstract of Weinakademiker Thesis

Mouthfeel in wine is an essential part of the enjoyment of its consumption. Not only do we sense the flavors in the wine, for which we use our taste and olfactory receptors, but we also notice physical effects, such as temperature, viscosity, and changes in the way in which the components of our mouth sense each other mechanically—in particular the frictional changes between the tongue and the palate. These effects are picked up by mechanoreceptors in the soft tissue in our mouths.

The term *astringency* has been used in the context of many foodstuffs, such as persimmons, or in beverages such as tea or wine. It refers to the drawing together of the soft parts of the mouth. There have been many studies of astringency in which attempts have been made to find its root cause in the chemistry of the food or beverage. Astringency has generally been ascribed to the presence of tannins: chemical substances belonging to the category of polyphenols, whose structures include many 6-membered aromatic rings and hydroxyl groups, and which show a marked tendency to polymerize and rearrange under mild aqueous conditions, such as those found in stored wine. The natural function of astringency in the wine grapes that produce these polyphenols is to taste repellent, for example to deter predators or to put off birds until seeds are ripe and can be usefully dispersed.

In recent years, a link has been made between astringency and the frictional changes described above, and a consensus has arisen in the community that wine astringency involves the interaction between tannin molecules and the lubricious components of saliva, resulting in a reduction of oral lubrication and therefore the sensation of increased tongue-palate friction. This results from two major interactions—hydrogen bonding and hydrophobic linkages—which can be influenced in different ways by the presence of other wine components.

The connection between astringency and the presence of tannins is strong but not absolute. Reputable studies have shown that not all tannins are astringent, and not all astringent food components are tannins. There is increasing evidence that there are even non-friction-related pathways for astringency sensing in the mouth, involving the trigeminal nerve, though the friction route still dominates. However, it is clear that there is not a single sensation of astringency. Wine-tasters are used to describing the tannin “quality” of wines, and food scientists have determined up to 30 distinct descriptors of astringent character, including frequently encountered descriptors, or “sub-qualities” such as *drying, pucker,* and *rough.*

Unlike the strong link between tannin and overall astringency, the chemical origins of these sub-qualities have been challenging to identify. This lies partially in our inability to characterize absolutely the very complex composition of wine, especially the larger molecules that tannins have a tendency to form. It is partially also due to interactions between all of the wine components, which complicates the picture still further.

An alternative approach is to analyze astringency effects *ex situ* by measuring the way in which saliva lubrication is affected by added wine. This involves the use of a special "tribometer," designed to measure the efficiency of oral lubricants between surfaces that resemble those present in the mouth. Such studies have been carried out over a number of years in several laboratories, worldwide, and are a useful way of quantifying the individual effects of wine components, singly or multiply, on the frictional behavior associated with astringency. These types of studies are even more valuable when combined with comprehensive chemical analyses, as well as with results from tasting panels, for the same set of samples—the entire, massive dataset being processed with advanced statistical approaches. In parallel with such studies, further insights can be gained into the interaction of wine components with salivary pellicles by means of surface-science methods that measure the mass and mechanical properties of thin layers. One approach involves the quartz-crystal microbalance with dissipation (QCM-D), onto which a pellicle can be cast, wine can be added, and the mass increase and mechanical-property changes measured.

In the last five years, a series of seminal papers has been published thanks to an Australian collaboration that uses the approach just outlined. Not only were the researchers able to rapidly demonstrate the involvement of tannins in the sub-quality of *drying,* but they could also show that *pucker* was an independent sub-quality that was more sensitive to sample pH than to tannin. *Roughness*, on the other hand, seemed to be a sub-quality that depended on *drying* or *pucker*. The parallel tribological studies revealed that the amount that friction was increased in a tribometer by adding wine to saliva was dependent on the amount of tannin in the wine, but it was the pH (only) that determined the *rate* at which friction increased when wine was added to a salivary pellicle. The QCM-D studies showed that the mechanism of friction increase involved irreversible tannin attachment to the salivary pellicle, the weakened layer then presumably being stripped off under the shear present in the mouth or in the tribometer.

Further understanding emerged from successive studies using the same approach: namely that low pH can trigger astringency sensations, even in the absence of tannin, that polysaccharides can mitigate the astringency effects of tannins by binding with them and inhibiting their interactions with salivary proteins, that ethanol can inhibit the astringent effects of tannin (via physical interactions that disturb the tannin-salivary protein binding), but that ethanol itself can also lead to drying sensations after expectoration/swallowing. Finally, it was determined that the astringency aftertaste profile of the wine is modulated by the interplay of titratable acidity and pH—in other words by the chemical makeup of the acidic components of the wine (balance between lactic, malic and tartaric acids).

The research is still in its infancy, and much remains to be done in method development if the results are to be used to advance the capabilities of the wine industry; but the potential is certainly there to tailor the mouthfeel of wine for particular consumer segments by means of a combination of vineyard and cellar techniques. An additional important commercial topic is the development of low/no-alcohol wines, where mouthfeel remains a significant challenge and where a greater understanding of the influence of individual wine components on the sub-qualities of astringency could be extremely valuable.