AVF Annual REPORT

I. Project Title: Investigation of mechanisms for perception of astringency

II. Principal Investigators: A. C. Noble (530-752-0387) Dept. Viticulture and Enology, University of California, Davis, CA 95616
Cooperators: Kevin Scott (SRA) and Dr. Inger Baek (post doc) Dept. Viticulture and Enology, and Professor C. F. Shoemaker, Dept. Food Science , University of California, Davis, CA 95616

III. Summary

Astringency has been shown to have carry-over effects which influences the perception of astringency of red wine and astringent compounds. To quantitatively measure this effect, trained judges rated intensity of astringency continuously while repeatedly sipping wine. When red wines were sipped 4 times at 25 second intervals between sips, the astringency intensity increased significantly with each sip. At each sip, astringency increased, reached a maximum intensity about 15-16 seconds after the sip was taken, then decreased slowly until the next sip was taken and again astringency increased. For two of the wines the increase with each sip was significant, whereas the other two the increase in astringency between the 3rd and 4th sip was not significant. To see what happened when more sips were taken, astringency was continuously rated over 8 sips for alum and tannic acid. The 4th sip of tannic acid was not more significantly intense than the 3rd , although the astringency continued to slowly rise.

The practical consequences of these results are that most evaluations of red wines are rendered invalid due to the carry-over phenomenon demonstrated in this study. Astringency of red wines evaluated either by a winemaker during winemaking or for blending or by wine show judges is influenced by the wines tasted before it. (In the attached proposal, research is outlined to minimize this problem).

To quantify the effects of physiological differences on perception of astringency the saliva flow rates of the judges in the red wine and alum/tannic acid studies above were determined. Individuals with low flow rates of saliva perceived astringency of red wine and of the alum and tannic acid more intensely and longer than high-flow subjects. This physiological difference in perception of astringency is of great significance in understanding how astringency is perceived. Since saliva flow rate varies with the size of the person generally speaking, the practical value of this information may lie in marketing wine, where it may account for preferences of "smaller" consumers.

In evaluations of the viscosity of saliva-tannin mixtures, it was shown that viscosity of saliva decreases when tannin is added, analogous to sipping red wine. This is consistent with the observations of the effect of salivary flow status. If astringency is felt as the friction resulting from precipitation of saliva proteins by tannins, than high-flow subjects can restore lubrication better and hence perceive lower levels of astringency than low-flow individuals.

IV. Objectives and experiments conducted

Overall objective: To understand how the factors listed below affect perception of astringency

A. The effect of consumption pattern on perception of astringency
B. The effect of physiological factors (saliva flow rate) and wine composition on astringency
C. The role of protein precipitation by tannins on oral lubrication (viscosity) and astringency

A. Experiments.

1. The effect of consumption pattern

A. Wine. Astringency of 4 red wines was evaluated by time intensity (T-I) methods by 18 trained judges. The intensity data was acquired each second using the Fizz Software (Biosystemes, Dijon).
B. Alum and tannic acid. Astringency of three concentrations of alum (and separately of tannic acid) were evaluated by time-intensity by 16 trained judges as they sipped 8 times at 25 second intervals. Samples were expectorated 8 sec after being sipped. Between samples, judges rinsed as described above for wine.

2. The effect of saliva flow-rate and wine composition

A. Wine. While judges took 4 sips of each of 4 red wines (as described above), saliva collected directly from the parotid salivary gland was weighed continuously.
B. Alum and Tannic acid. Using the method of Ishikawa and Noble (1995), whole mouth salivary flow was estimated in duplicate. Each person sipped 10 ml of 4g/l citric acid which was expectorated at 10 s into a weighed cup. For the next 50 seconds, subjects expectorated saliva into the cup. The weight of the collected saliva was used to estimate salivary flow status.

3. Role of tannin precipitation of proteins on oral lubrication(viscosity).

The viscosity of protein-tannin mixtures and saliva-tannin mixtures have been measured instrumentally. The protocol for using mouse tissue to assess the physiological affect of four astringents on the mucosal membrane in the mouth has been outlined. Each astringent will be applied in replicate to the mucine buccal mucosa for 20 seconds. Immediately following astringent application, a tissue section will be excised and fixed for histological tissue processing. Tissue will be examined via light microscope, and if necessary, via electron microscopy to characterize the change in epithelial structure. All astringents will be compared with a control group receiving no treatment.

4. Data analysis.

Using a basic program, many parameters were extracted from the smoothed raw time-intensity curves, as illustrated in appendix, Figure A. The parameters were analyzed by mixed model analysis of variance where judges were treated as a random variable.

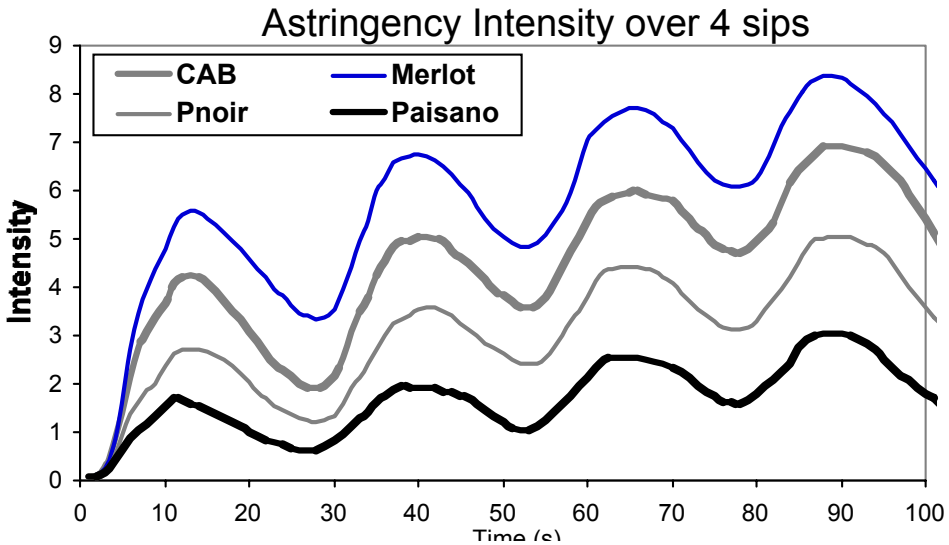
V. **Summary of Major Research Accomplishments and Results**

1. The effect of **consumption pattern**

A. Wine

As shown in Figure 1,the maximum intensity (IMAX) of each sip increased significantly with the number of sips. Similarly the lowest value of intensity reached between sips (Initial) also increased with sips. IMAX significantly increased between sips for each wine, with two exceptions. For Paisano the first two sips were not significantly different; and for the Merlot the 3rd and 4th sips did not differ significantly. Maximum intensity was reached about 15 sec after sipping or 9 sec after swallowing.

Figure 1. Average astringency over time for 4 sips of 4 red wines.



B. Alum and Tannic acid

For each compound over successive sips, IMAX and Initial astringency increased as illustrated in Figure 2. A rapid increase in astringency occurred immediately after each sip reaching a maximum intensity 6 to 8 s after expectoration then decreased until the next sip was taken whereupon the intensity increased sharply again. The lowest value of astringency between sips (initial value =init) increased significantly ($p<0.001$) as the number of sips increased, similar to the increase seen for the maximum astringency for each sip. The time to maximum intensity (examined only for the first sip) varied across the compounds. The average time to maximum intensity was 14.5 s for alum and 16.4 s for tannic acid.

However, in contrast to the Pinot noir and Cabernet wines, for which each sip was significantly higher than the previous one, sip 4 IMAX was not significantly higher than sip 3 for tannic acid. For alum sip 3 did not increase significantly over sip 2. For both systems, although the magnitude of astringency increased slightly over sips 6, 7 and 8, this was not a significant difference, suggesting a plateauing effect may have occurred by sip 5.

Figure 2. Average astringency curves over time for alum (top) and tannic acid (bottom).

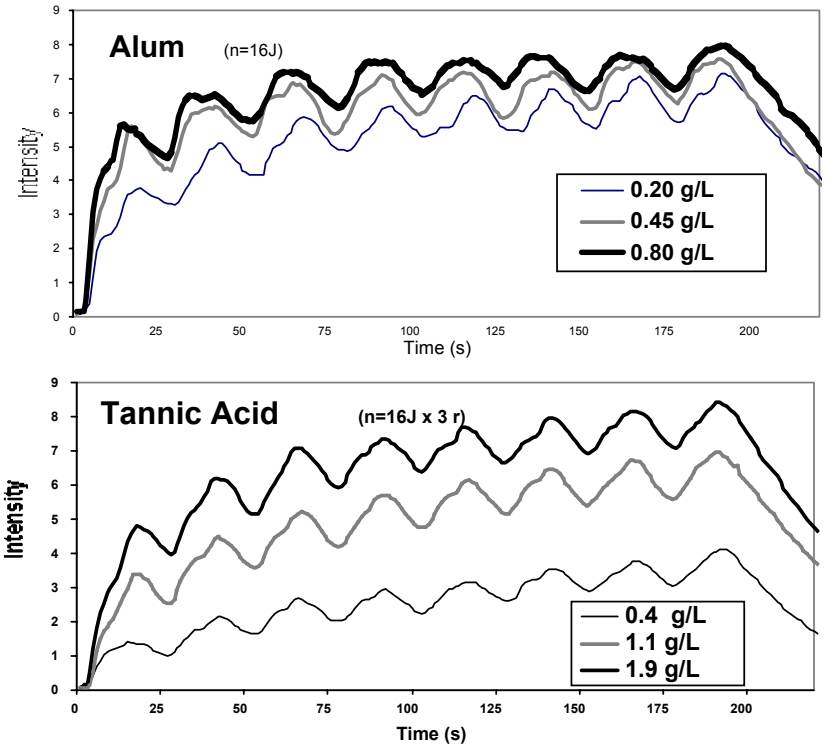
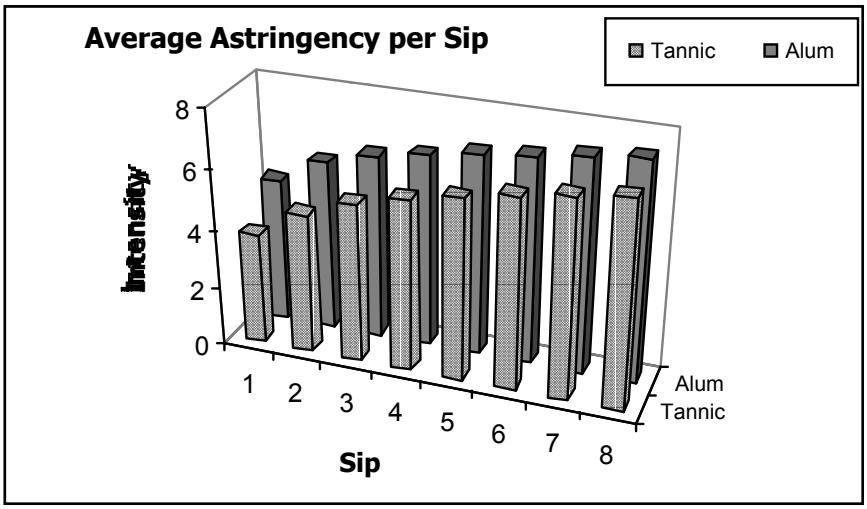


Figure 3. Average astringency maximum intensity by sip for alum (n=48) and tannic acid (n=144).



2. The effect of **salivary flow**

A. Wine.

Astringency intensity varied as a function of flow-group status when averaged across sips. As shown in Figure 4, the low flow group rated astringency higher than the high flow subjects, consistent with previous reports (Fischer et al, 1994; Ishikawa and Noble, 1995). This is of significance in understanding the mechanisms by which astringency is perceived

Accumulated salivary flow is given in response to sipping red wines in Figure 5. Although the wines varied in astringency (and pH), averaged across all judges the saliva flow varied only slightly in response to the different wines. In a previous study, salivary flow increased most in response to lower pH wines, and next by those higher in phenolics (Fischer, 1990). In contrast to the negligible difference in elicited flow rate between wines, the difference between judges is very large (Figure 5). These results are consistent with the difference in perception of astringency shown as a function of salivary flow status in Figure 4.

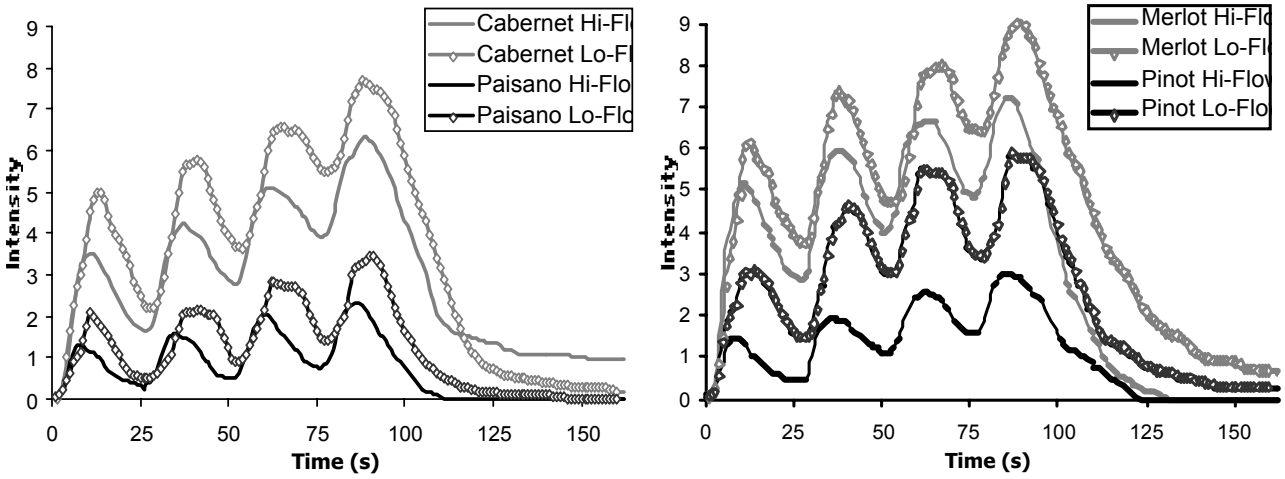


Figure 4. Average intensity of astringency over time for low-flow (n= 7) vs high-flow judges (n=5).

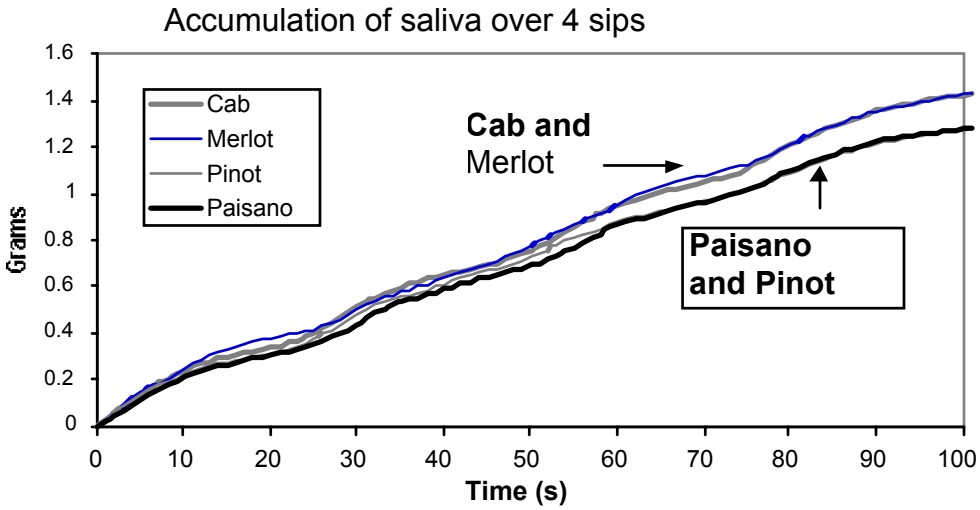


Figure 5. Accumulated parotid saliva (g) in response to 4 sips of red wines n=12jx3wx2r)

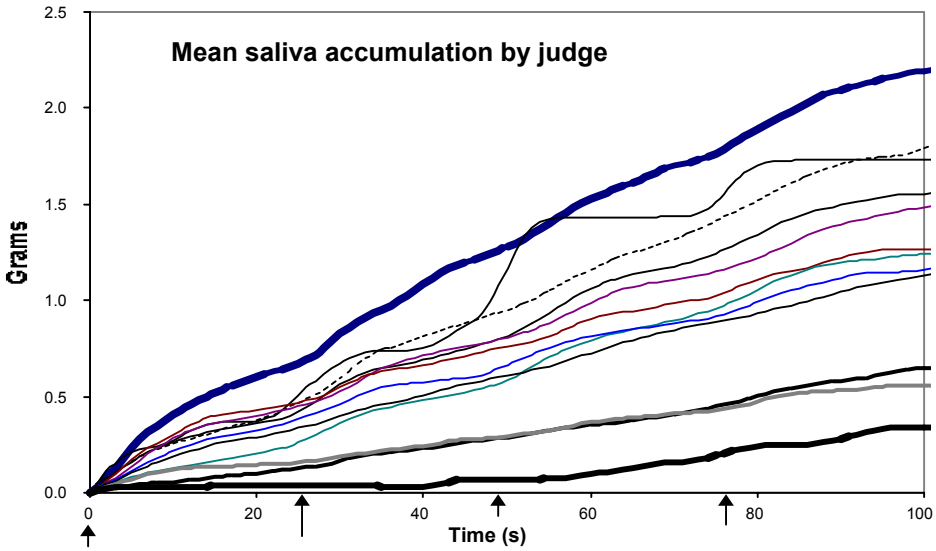


Figure 6. Average accumulated parotid saliva for each judge (n=4 wines x 2 reps). Time of each sip is noted with an arrow.

The salivary flow rates (not shown) were extracted from the accumulated flow curves. Rate of saliva production increased instantly as the wine was sipped at 25 s intervals peaking at about 5-7 sec after each sip then slowed and decreased until the next sip. Again, no significant difference between wines was observed, but the maximum flow rate decreased with subsequent sips, in contrast to previous reports in the literature which suggested that the output of salivary glands does not decrease.

B. Alum and Tannic acid

In contrast to the individual measurements of saliva flow obtained for responses to wines, in this study, judges were classified by the weight of saliva accumulated in one minute. For these 16 subjects, the range varied from 1.6 to 4.0 g/min. Judges were assigned to low (n=3) , medium (n=7) and high (n=6) flow rate status which had the following mean accumulation in grams (standard deviation): Low = 1.66 (0.11), medium = 2.58 (0.10) and high = 3.45(0.32).

The maximum intensity for each sip for each flow group is shown in Figure 6. Judges with low-flow have higher maximum astringency ratings for tannic acid and alum, than the medium-flow group, with the high-flow group having the lowest astringency ratings of all. These lower astringency ratings for high-flow subjects are consistent with results found previously (Ishikawa and Noble, 1995; Fischer et al.1994). When the differences in rating between flowgroups are compared for each sip, significant differences in IMAX astringency were found for the first 4 sips for tannic acid and 2 to 8 for alum .

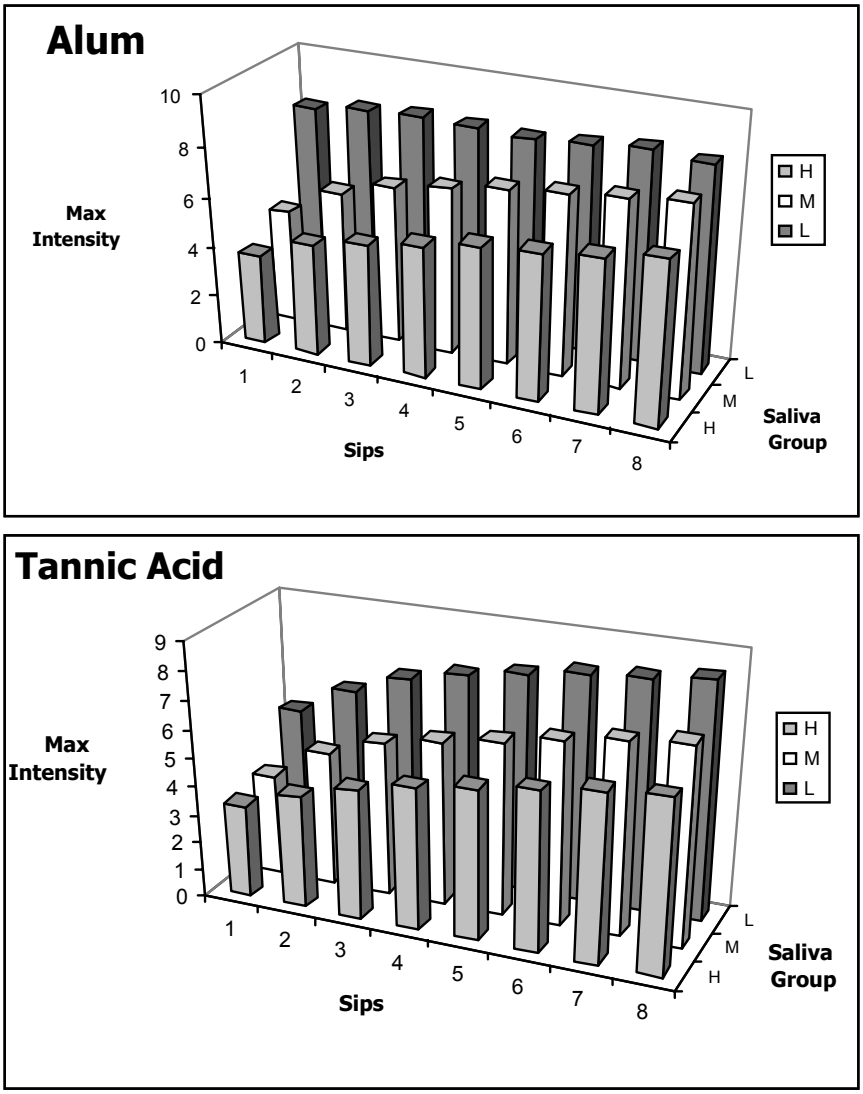


Figure 6. Mean maximum astringency ratings for each sip for each salivary flow group.

The pattern of astringency increase over sips changed slightly differently across systems and sips. For tannic acid and alum, low flow subjects rated tannic acid astringency higher than medium subjects, who in turn were also higher than the low flow subjects. For alum, the low flow subjects rated astringency much higher than the other subjects, rating at the high end of the scale from sip 1 to 8.

3. The role of protein precipitation by tannins on oral lubrication (viscosity) and astringency.
   The relative reduction in viscosity of saliva and proteins has been measured. Results for gelatin and saliva are shown in Figure 7. However, the data are still being processed (by student who was away for crush). Methods have been outlined for assessing the nature of the complex in the mouth between tannin and the oral mucosa. This work has just been initiated.

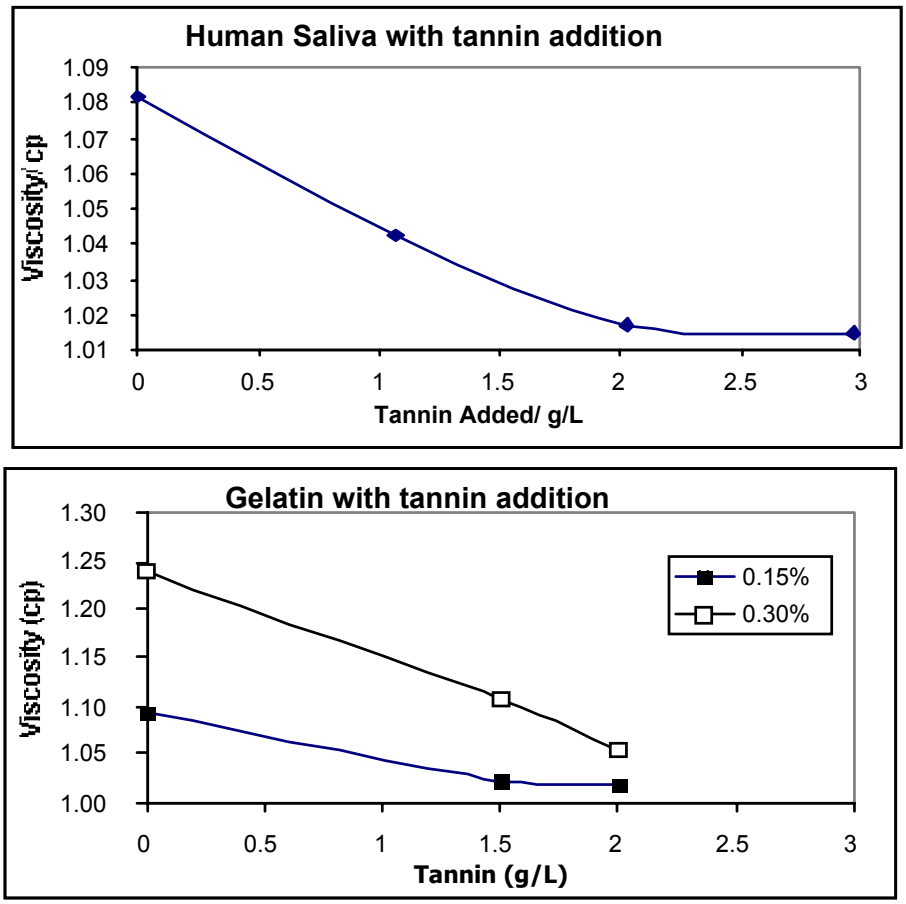


Figure 7. Viscosity of gelatin and human saliva systems after addition of tannin

Conclusion

For all three systems, astringency intensity increased across sips, although the rate of increase slowed such that by the 6 sip no further significant increase occurred. Intensity of astringency at each sip increased with concentration for each compound. Significant differences were found as a function of the salivary flow rate of the subjects: high flow subjects rated astringency lower for all sips and systems, than medium and low flow subjects.

References Cited.

1. Fischer, U., Boulton, R.B. and Noble, A.C. (1994). Physiological factors contributing to the variability of sensory assessments: Relationship between salivary flow rate and temporal perception of gustatory stimuli. Food Qual. Pref., 5, pp. 55-64.
2. Ishikawa, T. and Noble, A.C. (1995). Temporal perception of astringency and sweetness in red wine. Food Qual. Pref., 6(1), pp. 27-33.

Outside presentations of research:

May 12 1999 Seminar in Food Science seminar series: Comparison of the effect of stimulus, physiology and protocol on temporal perception of bitterness and astringency at Reading University, Reading

June 17 1999 : Noble: The taste of bitterness and feel of astringency.(Invited talk) Symposium: Touch, Tickle and Taste. University of Wisconsin, Madison, Wisconsin.

June 30 1999, Le Drean, E and Noble, A C Evaluating astringency of red wine using repeated Sipping to imitate Normal wine-drinking behavior. Am. Soc. Vit. Enol Annual Meeting, Reno, NV

Oct 5. 1999 Noble, A.C. Astringency of beverages. Effect of repeated sips and salivary flow-rates (Invited lecture) World Congress Food Sci and Tech. Sydney, Australia

Oct 8, 1999. Noble, A.C. Factors influencing perception of astringency. One day workshop for New Zealand winemakers, Taradale, N.Z.

Publications:

1999 Peleg, H., K. Gacon, and A.C.Noble. Bitterness and Astringency of Flavan-3-ol Monomers, Dimers and Trimers. J. Sci. Food Agric. 79:1123-1128.

2000 Noble, A. C. Factors influencing perception of bitterness and astringency in foods and beverages. INRA proceedings (Proceedings of International Polyphenolics Conference in Lille, France, 1998) in press.

2000 Noble, A.C. The taste of bitterness and feel of astringency. (Submitted to Chemical Senses).

Research Success Statements.

When red wine is being evaluated or consumed in social situations, the same wine is repeatedly sipped at short intervals. This pattern of consumption affects the perception of astringency of red wine and astringent compounds. When red wines were sipped 4 times at 25 second intervals between sips, the astringency intensity increased significantly with each sip The increase in astringency with subsequent sips or on evaluation of other samples is due to "carry-over" effects. The practical consequences of these results are that most evaluations of red wines are rendered invalid due to this carry-over phenomenon. Astringency of red wines evaluated either by a winemaker during winemaking or for blending or by wine show judges is influenced by the wines tasted before it. (In the attached proposal, an investigation to develop methods to minimize this problem is outlined).

Individuals with low flow rates of saliva perceived astringency of red wine more intensely and longer than high-flow subjects. This physiological difference in perception of astringency is of great significance in understanding how astringency is perceived. Since saliva flow rate varies with the size of the person generally speaking, the practical value of this information would lie only in marketing wine, where it may account for preferences of "smaller" consumers.

Funds. Expended.