***Enology Notes* #158** **June 29, 2011**

To: Grape and Wine Producers

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1. Factors Influencing Taste and Mouthfeel.

The following is a review of some of the major features regarding taste and mouthfeel. As we all know, if as a group we were to evaluate a wine, it is not likely we would have the same response to the product's attributes and deficiencies. Beyond that, without standardization, it is very difficult for individuals to provide a consistent response.

In proper wine sensory evaluation, we must keep the following confounding features in mind and minimize their effects.

Problems with non-standardized sensory responses:

- Adaptation
- Cross adaption
- Individual variability
- Difficulty in separating some sensory components
- Non-standardized language
- Expectations/bias

Our goal is to improve wine quality by enhancing our ability to understand the limits and potential of sensory evaluations.

Proper sensory evaluation at the winery involves the following:

- Standardized and controlled environment
- Representative sample
- Proper sample temperature
- Established common language
- Understanding the importance of sample contrasts
- Proper number of evaluators required to gain a true picture
- Using the proper testing method

Variation in sensory response can be the result of the following variations, which are outlined below:

- Genetic
- Biological
- Physiochemical
- Psychological

a. Genetic Variation. It is recognized that there are five primary tastes: sweet, sour, bitter, salty, and umami.

Taste is sensed by taste receptors located within the taste buds. There are four types of taste buds, and an average of about 9000 taste buds in adults. A taste component must be dissolved in saliva and physically enter the clove-shaped taste bud.

Taste acuity is:

- Positively correlated to the number of taste pores on the tongue; the average is 70 fungiform papillae per cm^2, but so-called hypertasters, or supertasters, possess more than 100 per cm^2.

- Many taste receptors can sense more than one taste; as such, the tongue does not have areas that detect certain tastes exclusively.
- Receptors of similar sensitivity are grouped together on the tongue.
- Individual receptor neurons may react differently to one or more compounds.
- Protein(s) associated with taste buds play a role in promoting taste reception.

We conducted a sensory exercise with winemakers that demonstrated the genetic variation among us with regard to perceiving a certain type of bitterness. The PTC test (blue paper) demonstrated variability as a result of genomics. PTC (phenylthiocarbamide) is a well-documented example of how dramatically people vary in their ability to taste bitterness. While this test is for certain types of bitterness found in wine, it has not been directly correlated with wine bitterness detection.

We evaluated two other test papers (yellow and pink) which contained thiourea and sodium benzoate, respectively. These papers highlight the differences in taste perception for simple compounds. Most evaluators suggested that the yellow paper was either bitter or had no taste, while the pink paper was perceived as sweet, salty, bitter, or no taste at all. It has been reported that a non-taster of the PTC will not note a bitter taste response to the sodium benzoate.

If a single chemical component can elicit a multitude of different descriptors, it is not difficult to imagine why, in a complex matrix such as wine, we have trouble reaching a consensus.

b. Biological Variation. In order to taste something, the tastant must be dissolved in or mixed with saliva. The number of both taste buds, and sensory receptors per taste bud, declines past middle age, although age-related sensory loss is not known to seriously limit wine tasting ability.

There is about a 10-fold difference in saliva production among humans. Taste receptors are replaced every 7-10 days. There is less reception in smokers and the elderly, where cell regeneration may be slow.

Wine stimulates salivary flow, which both dilutes and modifies wine chemistry. The proline-rich proteins of saliva, which make up about 70% of salivary proteins, effectively bind tannin. The result is to reduce bitterness by lowering their ability to react with bitter-sensing receptor proteins.

Saliva chemistry changes throughout the day (affecting its buffering action) and often differs between individuals. People also differ notably in their saliva flow rates which, among other things, can affect how quickly an individual may react to tastants (Fischer et al., 1994).

Acuity is generally measured as a detection threshold, the lowest concentration at which a substance can be detected. Thresholds differ notably among individuals and classes of wine components.

Adaptation is a short-term loss in acuity, associated with extended exposure to a tastant. Adaptation to a tastant can become complete. It is recommended that wine evaluators properly cleanse their palate and sense of smell between samples.

Cross adaptation refers to the effect of adaptation to one compound affecting perception of another. Some of the effects are easy to comprehend, for example the apparently sweet sensation of water after tasting bitter or acidic solutions.

Cross adaptation can occur in a multiple-comparison evaluations where wine one has a lingering effect on wine two. In an example conducted during a winemakers sensory training session, we tasted lemonade, followed by what I suggested was water. The water (which actually contained some sugar) impacted the perception of the sugar/acid balance of the lemonade (McBurney and Bartoshuk, 1973).

Tasting order can have an impact on wine perception due to cross adaptation. Order error refers to the differences in perception owing to the order in which wines are sampled. This is why, in a true sensory evaluation, all evaluators would not taste the wines in the same order.

c. Physicochemical Variation. We know that wine balance can be viewed as the reciprocal-type relationship indicated below. An increase in the perception of components on the left side decreases the perception of components on the right.

Sweet/Body ↔ Acid + Phenols (tannin intensity, astringency, dry tannins and bitterness)

Palate balance is impacted by a number of features, including temperature:

- Cooling reduces sweetness of sugars
- Cooling reduces bitterness of alkaloids
- Cooling increases the sense of acidity
- Cooling increases bitterness and astringency of tannins

Wineries generally serve all their whites at one temperature, and all their reds at another. Based on the palate balance relationship, this may not be optimal.

Sugars. Sugar concentrations above 0.2% are generally required to exhibit perceptible sweetness. When sweetness is detected in dry wines, it is usually due to the presence of a noticeable fruity fragrance. Association between fruity odors and sweetness has trained us to instinctively affiliate the presence of fruity odors with sweetness, even in its absence (Prescott, 2004).

Sugars begin to have a pronounced influence on sweetness and affect the perception of body at concentrations at or above 0.5%. The influence of aromatics on the perception of the sweetness of sugar can be very important. Thus, the fragrance of a wine may not

only evoke the perception of sweetness, but also increase the perceived intensity of sweetness. We discussed this in relationship to rosé wine production.

Body. Despite the importance of body to the overall quality of wines, its precise origin remains unclear. Gawel et al. (2007) found a correlation between higher ratings for flavor and/or perceived viscosity with body. In sweet wines, body is often viewed as being roughly correlated with sugar content. In dry wines, it has often been associated with alcohol content.

There is evidence that the macromolecular content of wines (yeast proteins and polysaccharides) may play a role in the overall perception of body (Vidal et al., 2004a, b). Features such as a wine's fragrance can influence the perception of body and, conversely, increasing the sugar content can increase the perception of fragrance.

Polysaccharides. Polysaccharides, either grape- or yeast-derived, play a role in reducing acidity and astringency. They add to the perception of sweetness/body and thus lower the perception on the other side of the palate balance relationship. This influence can be significant, and is the basis for the interest in yeast fining and some commercial addition products.

Alcohol. Ethanol possesses a sweet aspect. The acidity of wine diminishes as the alcohol increases. Ethanol slightly enhances the sweetness of sugars, while reducing the perception of acidity. At high concentrations (above 14%), alcohol increasingly generates a burning sensation and may contribute to the feeling of weight or body, especially in dry wines.

Acids. The effect of acidity in diminishing perceived sweetness appears less than that of sugar in suppressing the perception of acidity (Ross and Weller, 2008). Of the common acids found in wine, malic acid is the most sour tasting, whereas lactic acid is generally considered the least sour.

The perceived intensity of a mixture generally reflects the intensity of the dominant component, not a summation of their individual effects (McBride and Finlay, 1990).

pH also impacts taste perception, both directly by influencing the ionization of salts and acids, and indirectly affecting the shape and biological activity of proteins. Structural modification of receptor proteins on gustatory neurons could significantly affect taste responsiveness.

The use of oral hygiene products, which can impact taste buds, make most wines taste much more of acidity. The so-called Orange Juice Effect is the result of sodium lauryl sulfate (or sodium dodecyl sulfate, two names for a common toothpaste ingredient) that can react with taste buds (DeSimone et al., 1980). This is a primary reason why sensory evaluations are generally not conducted too early in the morning.

Saltiness. The salt of some cheeses can suppress the bitterness of red wines. These influences may or may not affect response time, duration, and maximum perceived intensity.

Taste- and mouthfeel-components can affect taste:

- Ethanol enhances the perception of sugar-induced sweetness.
- Ethanol suppresses the astringency of tannins.
- Ethanol enhances flavonoid-induced bitterness (Noble, 1994) when the alcohol level is relatively high.
- Acids increase the perception of bitterness and astringency.

Mouthfeel. Mouthfeel is a generalized term used to describe the multiple sensations of the following:

- astringency
- touch
- viscosity/body
- burning
- temperature
- prickling from carbon dioxide
- pain

The combination of these sensations with those from the nose produces the perception of flavor. Unlike gustatory and olfactory sensations, mouthfeel activation occurs slowly, and adaptation is also slow or may not develop. Adaptation is particularly evident in the increased intensity of astringent sensations on repeated exposure to red wines, consequently, the use of palate cleansers is recommended during tasting.

Astringency and Bitterness. Astringency is primarily induced by flavonoid tannins that come from grape seeds and skins. Anthocyanins can enhance the perceived astringency of tannins, but do not contribute to wine bitterness (Brossaud et al., 2001).

Astringency is commonly confused with bitterness. Both perceptions develop comparatively slowly and possess lingering aftertastes.

Astringency may partially mask bitterness (Arnold and Noble, 1978), and is more often confused with bitterness than the inverse.

Astringency is thought to result from the binding and precipitation of proline-rich salivary proteins and glycoproteins with phenolic compounds. pH affects protein hydration and ionization of both phenol and protein.

Astringency is one of the slowest in-mouth sensations to develop. Depending on the concentration and types of tannins, astringency can take up to 15 seconds before reaching maximal intensity. The decline in perceived intensity occurs even more slowly.

The intensity and duration of an astringent response often increases with repeat sampling (Guinard et al., 1986). This phenomenon is less likely to occur when the wine is consumed with food, owing to reactions between tannins and proteins in the food, as well as due to dilution.

Mouthfeel time intensity characteristics include the following:

- Activation occurs slowly.
- Adaption occurs slowly, as evidenced by increased intensity upon repeated exposure.
- Astringency intensity and duration often increase with repeated exposure.
- Interaction of salivary proteins can be blocked by incorporation of lees peptides and other sulfur-containing side groups.

Molecular size is one of the more important factors influencing tannin-induced astringency. Bonding is roughly correlated with molecular size (polymerization). Steric hindrance (geometry) limits the availability of some binding sites.

Phenol features and relationships include the following:

- Lower pH equates to higher perception of astringency.
- Higher alcohol generally lowers perception of astringency and increases perception of bitterness.
- Increased polymerization augments drying, chalky, grainy, puckery attributes.
- Increased galloylation (flavonoids esterified with gallic acid) augment rough or course attributes, as well as dryness (Vidal et al., 2003); galloylated tannins are common in seed tannins.
- Velvety astringency in reds is positively correlated with flavonol glycosides.
- Positive correlation between color and perceived tannin “quality.”
- Incorporation of anthocyanins terminates tannin polymerization.
- Generally, greater color is correlated with finer tannins.
- Flavanone glycoside and tyrosol produced by yeast contribute to the slight bitterness of white wines.

Phenols can often have more than one sensory response. In mixtures, this can significantly affect overall taste quality. For example, small tannins (small molecular weight polymers) may be both bitter and astringent.

The interaction of taste and mouthfeel components forms the basis of food and wine pairing. For a discussion of food and wine pairing exercises you can conduct at the winery with your clients, see Food and Wine Pairing at www.vtwines.info.

Additionally, for examples of how to determine wine preferences with regard to taste and mouthfeel elements, go to www.yumyuk.com and take the Taste SQ interview.

d. Psychological Variation. We know that color, bottle shape, closure type, etc., creates a certain bias for or against, which can influence our perception of the product. Bias must be eliminated if a true sensory impression is desired. The development of bias often has cultural origins, expressed in ethnic differences in odor/taste judgments.

2.Volatile Acidity.

The following is adapted from Zoecklein et al. (2005). The total acidity of a wine is the result of the contribution of nonvolatile or fixed acids, such as malic and tartaric, plus those acids separated by steam volatilization, or volatile acids. A measure of volatile acidity is used routinely as an indicator of wine spoilage.

Although generally interpreted as acetic acid content (in g/L), a traditional volatile acidity analysis includes all those steam-distillable acids present in the wine. Thus, significant contributions to volatile acidity (by steam distillation) may be made by carbon dioxide (as carbonic acid), sulfur dioxide (as sulfurous acid) and, to a lesser extent, other organic acids.

a. Microbiological Formation of Acetic Acid. The volatile acidity of a sound, newly-fermented dry table wine may range from 0.2 to 0.4 g/L. Increases beyond this level, however, may signal microbial involvement and potential spoilage. The principal source of acetic acid post-fermentation in stored wines is attributed to growth of acetic acid bacteria and certain lactic acid bacterial species.

b. Formation of VA by Spoilage Yeasts. In some cases, high levels of volatile acidity may result from growth of yeast during fermentation. There is considerable variation in production of acetic acid and other byproducts among both native and cultured wine yeast strains of *Saccharomyces* spp.

Among those yeasts involved in acetification of wine, *Brettanomyces* is known to produce relatively large amounts. In one study, acetic acid production by *Brettanomyces* in white wine after 26 days of incubation (28°C/82.5°F) increased from 0.31 g/L to 0.75 g/L.

Acetic acid is a normal by-product of yeast growth and has its origin primarily in the early stages of fermentation. Several intrinsic and extrinsic factors may affect formation of acetic acid by yeast, including the following:

- pH
- Sugar
- Available nitrogen
- Fermentation temperatures
- Interactive effects of other microorganisms
- *Botrytis* and other fruit fungi

pH impacts acetic acid production, with more acetic acid produced at low (<3.2) pH.

The effect of increased osmotic pressure, resulting from high-sugar musts, on volatile acid formation is well known. Such fermentations typically have a longer lag phase with reduced cell viability and vigor. Generation time (budding) is also delayed. At initial fermentable sugar levels above 20%, acetic acid increases with sugar level and has been found to range from 0.6 to 1.0 g/L in musts of 32 to 42°Brix (17.7 to 23.3°Baumé), compared with controls at 22°Brix (12.2°Baumé) with acetic acid of 0.4 g/L. Visually, yeast cells growing under conditions of high osmotic pressure appear stressed.

Must nitrogen levels may also play a role in acetic acid formation. When available nitrogen is low, higher initial sugar levels (as seen in over-ripe or mold-damaged fruit) may lead to increased production of acetic acid.

Fermentation temperature is also known to affect the levels of acetic acid produced by wine yeasts. An early study found that volatile acid formation increased with increased fermentation temperature, over the range of 15°C (59°F) to 25°C (77°F).

Significant differences between yeast strains have been reported. In one study, it was noted that the formation of acetic acid was maximal at 40°C (104°F) in one strain of *S. cerevisiae*, whereas maximum formation occurred at 10°C (50°F) in a second strain.

Unless controlled, the temperature of fermentation may rise to a point at which it becomes inhibitory to wine yeast. In practice, inhibition may be noted at temperatures approaching 35°C (95°F) or higher. Because acetic and lactic acid bacteria can tolerate temperatures higher than those needed to kill (inhibit) wine yeasts, stuck or protracted fermentations often are susceptible to secondary growth of these organisms.

Pressure fermentations may also result in higher than expected volatile acid content, possibly due to selective inhibition of wine yeasts and growth of lactic acid bacteria.

c. Post-Fermentation Sources of Volatile Acidity. Cellar practices play an important role in volatile acid formation in stored wines. High levels of VA may result when headspace (ullage) is allowed to develop. In this case, the combination of oxidative conditions and surface area may support rapid growth of both bacteria and yeast. Because acetic acid bacteria are aerobic (air requiring) organisms, depriving them of oxygen is a viable means of controlling further growth. However, controlling growth requires a significant reduction in oxygen (to about 0.5 percent). Wood cooperage does not provide the complete airtight (anaerobic) environment needed to completely inhibit growth of air-requiring organisms.

Acetic acid bacteria may survive and grow at low oxygen levels present even in properly stored wines. Viable populations of *Acetobacter* present in properly maintained wines in wood cooperage can survive in low numbers. The bacteria can survive due to slow exchange of oxygen (approximately 30 mg/L/year) into the wine. Transitory exposure to air, such as may occur during fining and/or racking operations, may be sufficient to stimulate growth. Although the exposure may be short term and the wine is subsequently stored properly, incorporation of oxygen can support continued growth of

the bacterium. The problem becomes more apparent with increases in cellar temperature and wine pH.

During proper barrel storage, a partial vacuum develops within the barrel over time. Both water and ethanol diffuse through the wood and escape to the outside as vapor. In cellars where the relative humidity is less than 60%, water is lost from the wine to the outside environment, and the alcohol content of the wine increases. Conversely, where a higher relative humidity exists, alcohol is lost to the outside environment. Diffusion of water and ethanol through pores in the staves creates a vacuum in the properly-bunged barrel. Thus, even though some headspace may develop under these conditions, the oxygen concentration is very low. Formation of a partial vacuum in the headspace requires tightly-fitted bungs. Topping sealed barrels too frequently results in loss of vacuum and may accelerate both oxidation and biological degradation of the wine.

The volatile acidity of properly maintained barrel-aged red wines may increase slightly without the activity of microorganisms. An increase in volatile acidity of 0.06-0.12 g/L as acetic acid is inevitable after one year in new wood, not as a result of biological degradation, but due to hydrolysis of acetyl groups in the wood hemicellulose, and the result of coupled oxidation of some wine phenolics.

Although the practice is not recommended, winemakers forced to store wines in partially filled containers often blanket the wine with nitrogen and/or carbon dioxide. Nitrogen is the preferred blanketing gas, because of its limited solubility in wine. Sparging of wines (introduction of micron-size bubbles) with carbon dioxide is a better practice, allowing the gas to dissolve in the wine. Upon standing, the gas escapes slowly from solution and, due to its density, remains at the wine's surface to offer a degree of protection against oxidative deterioration and partially controlling air-requiring microorganisms.

d. Acetate Esters. The volatile character or "acetic nose" is not exclusively the result of acetic acid. Acetate esters, most specifically ethyl acetate, contribute significantly to this defect, providing an odor of nail polish remover.

Factors that can influence formation of acetate esters include yeast strain (as well as presence and population density of native yeasts), temperature of fermentation, and sulfur dioxide levels.

The growth of *Hanseniaspora uvarum* and *Kloeckera apiculata* yeasts during the early phase of fermentation results in significant production of ethyl acetate. These species frequently represent the dominant native yeast flora, and their numbers may increase significantly, even in fermentations inoculated with active *Saccharomyces* starters. Other native yeast species are known to produce substantial amounts of ethyl acetate (and other spoilage esters).

e. Ethyl Acetate and Spoilage. Although high acetic acid content and the presence of ethyl acetate are generally associated with each other, they may not always be produced to the same extent. Ethyl acetate levels of 150 to 200 mg/L impart spoilage

character to the wine. It has been suggested that a maximum ethyl acetate level of 220 mg/L be used, rather than traditional analyses of acetic acid as an indicator of spoilage. This suggestion is based on the fact that high acetic acid content does not always confer spoilage in the wine. A volatile acid content of less than 0.70 g/L seldom imparts spoilage character and, in combination with low concentrations of ethyl acetate, may contribute to overall wine complexity.

Acetic acid and ethyl acetate levels in unfermented must have also been examined as indicators of spoilage in grapes.

f. Sensory Considerations. Volatile acidity magnifies the taste of fixed acids and tannins but, itself, may be somewhat masked by high levels of sugar and alcohol. This may help explain why VA can be sensorially detected in some wines at relatively low levels (<0.5 g/L), whereas in others it is not noticeable at even higher concentrations.

g. Reduction of Volatile Acidity. Both TTB and the OIV regulate the levels of volatile acidity (expressed as acetic acid) in domestic wines offered for sale. In California, more restrictive regulations apply.

Reduction of high volatile acidity in wines is difficult. Attempts to lower volatile acid levels by neutralization generally yield undesirable results, because of concomitant reduction in the fixed acid content. Similar problems (flavor and aroma stripping and modification) are encountered in the use of ion exchange. Reverse osmosis has proven successful. Use of yeast for volatile acid reduction has also been studied; the application takes advantage of oxidatively-growing yeasts using acetic acid as a carbon source. Utilization of acetic acid by active yeasts has led some winemakers to add high volatile acid wine to fermenting musts to lower volatile acid levels. However, such practices run the risk of contaminating the entire lot, and may have a detrimental impact on fermentation, as well as on final wine quality. Judicious blending is probably the best practice to use in lowering the volatile acid content of borderline wines.

h. Controlling Microbial Growth in Wine. There are a number of steps that can be used to help control microbial growth in wine which, collectively, can be effective. Each of the features below has been outlined in editions of *Enology Notes*, available at www.vtwines.info. Click “Enology Notes” and “Enology Notes Index”:

- Proper sanitation
- Proper sanitation monitoring
- Lysozyme
- Sulfur dioxide
- Temperature
- Oxygen management

3. Winery Sustainability and Design Workshop. This one-day workshop, led by Dr. Bruce Zoecklein of Virginia Tech, will address a variety of topics relevant to both those in the planning stage as well as established wineries looking to upgrade or expand their

facility. Topics include winery design and design pitfalls, sustainable winery architecture, sustainable practices and monitoring, winery and tasting room design and marketing, and winery business and licensing issues.

This program will be held at the Trutter Center, Lincoln Land Community College, Springfield, IL, July 9th 2011 and is sponsors by: The Illinois Grape Growers and Vintners Association and Lincoln Land Community College

For more information go to www.illinoiswine.org or contact Megan Pressnall, Director of External Relations for the IGGVA: mpressnall@extension.uiuc.edu

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