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# Technology has improved wine quality

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A. Dinsmoor Webb

**Q**uality in any wine is a function of the potential quality in the grape and the skill of the enologist in converting that grape to wine. The first control of ultimate wine quality starts with analyses of the grapes in the vineyard, where two attributes are of primary importance. To be palatably balanced—that is, not thin or overly alcoholic—the wine must be made from grapes containing the appropriate concentration of natural sugars. Too little sugar results in watery, thin, and unpalatable wines. Too much alcohol results from grapes left on the vine until they are overripe; these wines, perhaps suitable as dessert accompaniments, are simply too alcoholic to be used with meals.

Grapes are also monitored for acidity during ripening. Acidity is particularly important for clean, fruity, balanced tastes. As the grape ripens, the acids tend to disappear. The vineyardist must harvest before the acid level has decreased too much. Low acidity is also undesirable because it often leads to problems with fermentation and preservation of the wine which manifest themselves as undesirable tastes in the final wine.

Two other attributes of the grape—pH and aroma—are frequently monitored during the ripening process. The enologist cannot do much to control either of these characteristics, but it is desirable to know their magnitude, because they influence the quality of the final wine. The pH is a measure of the hydrogen ion activity in the grapes and is related in a complicated way to the taste of the grape and the wine, to the flavors generated during fermentation, and to the ease with which various bacteria can attack the wine during or after its fermentation. University of California research shows that very low values of pH usually correlate with immature grapes that yield excessively acid wines. Conversely, high pH grapes yield flat, alcoholic, and frequently bacterial wines. The pH of the grape, a function both of the soil type and of the vine's water regime, can be controlled to a small extent by frequency and amounts of irrigation.

Fruity and characteristic varietal aromas of grapes are the result of the presence in the fruit of volatile organic compounds. U.C. studies have shown that the absolute amounts and the relative concentrations of the compounds constituting the total aroma fraction vary with the grape variety, climate, and cultural practices. Although these latter factors can influence the aroma composition in ways not too well understood at present, we have found that the major influence is certainly the climate and particularly the temperature during the two to three weeks before harvest. High temperatures can volatilize some of these compounds.

Analytical methods for sugar and acid in grapes were first used in determining the suitability of varieties to different climates after 1880 by University researchers. Measurements of pH as a routine determination came with the development of the glass electrode pH meter in the 1930s and measurement of grape volatiles awaited gas-liquid chromatography of the late 1950s. Analyses of volatiles remain special rather than routine today.

Quality control during harvest and crushing is particularly important. The various components—sugars, acids, phenolics, enzymes—formerly neatly separated from one another, are mixed

together on crushing of the grapes and are exposed to the oxygen of the air. California research has shown that, depending on the variety, temperature, and speed of processing, changes can be profound and rapid. Because most changes are undesirable, modern enological practice encourages low temperatures to slow the reactions, prevention of exposure to oxygen, and rapidity of processing to minimize the time in which reactions can occur. Practically, these mean machine harvesting under cool nighttime temperatures, addition of sulfur dioxide or inert gas blanketing to minimize exposure to oxygen, and the use of modern harvesting, crushing, pressing, and transporting equipment to speed all operations.

Winemaking itself is traditionally thought of as starting with the crushing of the grapes and the addition of the yeast to conduct the fermentation. With today's technology, however, crushing and frequently pressing can be considered the final steps of the vineyard program. Quality control is critically important. University research has emphasized the need to consider exposure to oxygen, control of the extraction of materials from the skins, control of the temperature during fermentation, monitoring of sugar disappearance, and control of the malo-lactic or other bacterial fermentations.

Phenolic compounds in the juice of crushed berries contact oxygen and the enzymes that can catalyze oxidation of these compounds. The extent and rate of oxidation vary with the different phenolics present in different grape varieties. The brown color and oxidized flavor produced are always detrimental to quality in white table wines and occasionally in reds. Prevention of exposure to oxygen or inactivation of enzymes controls oxidation. Removal of phenolic compounds from the juice is not practical. Enzymes are inactivated by heating the mixture of juice and skins, but that damages the flavor of the wine. Inert gas blanketing to prevent exposure to oxygen or generous additions of sulfur dioxide to react preferentially with the oxygen are methods of dealing with the problem. Sulfur dioxide controls oxidation in wines, but too much gives the wine a very unpleasant flavor. The preferred method is to avoid oxygen exposure. Fortunately, modern stainless steel equipment and the ready availability of food-grade nitrogen or carbon dioxide make the technique feasible.

Analytical methods for sulfur dioxide determination are old but have been significantly improved by U.C. research within the past ten years; a special electrode for dissolved oxygen is of recent development. Techniques for measuring phenols and enzymes are still being developed in the U.C. enology laboratories, as are more precise methods of measuring residual sugars and the many acids of grapes and wines.

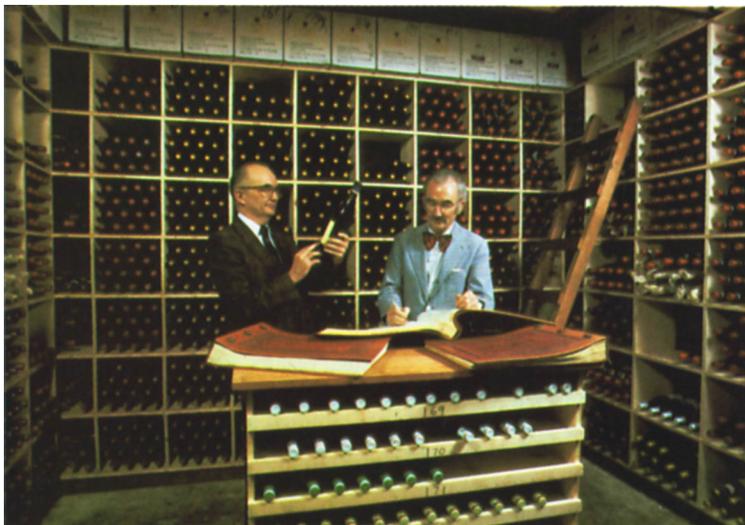
Waste heat liberated during alcoholic fermentation can lead to excessive temperatures in the wine, damaging the flavor and killing the yeast before all of the sugar has been fermented. U.C. research illustrates the importance of measuring tank temperatures and their rates of change. Temperature sensors in each tank now record temperatures electronically and control flow of cooling fluid to the tanks.

Winemakers follow the rate and extent of fermentation by successive measurements of the density of the fermenting medium. This works, because sugar solutions are considerably denser and alcoholic solutions less dense than water. Normal practice today is to use density measurements as a monitor until no significant changes are noted in successive readings.

It becomes critical, then, to know whether all of the sugar has been fermented or whether the yeast has simply ceased activity. Low concentration of sugar can be attacked by bacteria. Laboratory methods for sugar determination are usually based on purely chemical procedures or on enzymatic techniques. Most of the enzy-

matic procedures determine the concentration of glucose. University researchers are trying to find methods that will determine both glucose and fructose separately, for either can be present. Both of these sugars are susceptible to attack by bacteria with the production of off-flavors and clouds.

The malic acid in grape juice and wines is readily metabolized by a number of different bacteria to yield lactic acid and carbon dioxide. This reaction can occur during the alcoholic fermentation or later. The net effect of the malo-lactic fermentation is a decrease in the titratable and tastable acidity of the wine. In wines of excessive acidity it is desired, but in low-acid wines the malo-lactic fermentation can be a disaster. The juice and wine must be analyzed for concentrations of malic and lactic acids during fermentation and processing of the wine. Of the many possible



Conservatively valued at over \$250,000, the 3,000-bottle L. C. Jacobson collection of classical European wines was given to the University in 1979 by the Arizona businessman for use in teaching and research. Wine-aging specialist Vern Singleton and department chairman A. D. Webb check out a vintage from a high-security special storage cellar.

laboratory procedures for analysis of these two acids, high-pressure liquid chromatography and enzymatic methods are proving to be the quickest and most reliable. Close approximations can be obtained by older, simple paper chromatographic procedures developed by the University.

Following the primary and malo-lactic fermentations, wines are usually clarified by racking, filtration, or centrifuging, and transferred to the blending, aging, and finishing cellars. Here analyses to ensure that the bottled wine will remain biologically and chemically stable for a reasonable lifetime become critical. Biological stability was attained in older times by long cellar aging. In the 1860s Pasteur discovered that microorganisms in bottled wines could be killed by heating the filled and closed bottle. Pasteur considered the flavor changes good, but these are avoided by the recent procedure of sterile filtration and aseptic bottling, developed at the University of California and in Germany. Very careful microbiological testing is required to ensure that this latter technique is successful.

Chemical instabilities in wines arise from bottling wines supersaturated with potassium acid tartrate, from unstable proteins, or from excessive iron or copper. U.C. research shows that these potential problems can be avoided by careful analyses of the wines and their proper treatment, if required, before bottling.



Precise analytical methods permit enologist A. D. Webb to determine in exquisite detail the composition of grapes and wine. U. C.-developed procedures have significantly improved California wine quality.

Not only are the details of wine production very closely specified and supervised by both federal and state authorities to ensure that wines are wholesome foods, but strict federal and state regulations govern the concentrations of a number of the components of wines. Thus, it becomes essential that the chemical control laboratory monitor each production lot to make sure that it meets the federal and state specifications. Most frequently measured are alcohol, volatile and non-volatile acid, and sulfur dioxide concentrations.

## Conclusions

Analytical methods in the past century have permitted California researchers to gain detailed knowledge about the sugars and acids present in grapes and their changing concentrations during the wine-making operation. Analysis and control of oxidation through measuring both oxygen concentrations and sulfur dioxide concentrations in grape juice and wine have resulted in significant improvements in wine quality. U.C. researchers have also perfected analytical procedures for quality control during the past century to guarantee microbiological and chemical stability in bottled wines.

The various chromatographic methods—gas-liquid partition, high-pressure liquid, and thin-layer—permit U.C. scientists to determine in exquisite detail the composition of grapes and wines. Great progress is being made in correlating these analytical laboratory findings with quality in the bottled wine. The enologist now has techniques available to ensure, with a high level of confidence, the quality of our wines. Grape and wine analytical methods date from the start of the scientific revolution of the late 18th century. University of California researchers have contributed significantly to the refinement of older methods and the development of many new ones since the 1880 start of studies on grapes and wines.

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Red light masks the color in a sensory evaluation of wine by A. C. Noble. Opaque glasses are also used to eliminate influence of color on wine tasters.

Over the past 100 years the art of sensory evaluation of wines has been advanced to a science, in large part through research performed at the University of California. Initially, sensory evaluation was a necessary but informal and perfunctory part of assessing wine quality. However, even as an unrefined observational tool, it contributed to early grape and wine research.

In 1935 Professor William Cruess proposed three separate 100-point scorecards for rating white and red table wines and dessert wines. Later, basic guidelines also were suggested whereby wines were to be judged for freedom from defects and "trueness to type." With the original scorecards as a starting point, M.A. Amerine and A.J. Winkler developed a 100-point scorecard to provide more objective evaluations of wine by "freeing the tasters of preconceived ideals." Points were assigned on: appearance 10, color 10, odors 15, volatile acidity 10, total acidity 10, dryness 8, body 6, taste 15, smoothness and astringency 10, and general quality 8. From 1935 to 1959 the 100-point scorecard was used in evaluating wine grape varieties in the five climatic regions of California. From these accumulated data, extensive recommendations were made to the wine industry for the most suitable grape varieties to plant in specific regions.

Recognizing that, of the 100 points on the scorecard, the range from 70 to 79 was used almost exclusively, the Davis 20-point scorecard was then proposed with the following point distribution: appearance 2, color 2, aroma and bouquet 4, volatile acidity 2, total acidity 2, sugar 1, body 1, flavor 2, astringency 2, and general quality 2. Since its introduction, the 20-point card has been used for most overall wine evaluations in subsequent varietal trials and in most of the viticultural and enological studies performed at the University. Although the 20-point scorecard was later shown to have an effective range of only 5 to 7 points, it has been consistently used.

In 1952 U.C. researchers were the first to examine tasting results by analysis of variance. This statistical technique, now widely used, removes subjectivity from sensory evaluation by establishing judge reliability and consistency, as well as by testing the significance of the results.

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## Wine tasting is a science

A.C. Noble

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In the early 1960s the importance of scoring wines by region and by type was demonstrated. Since a judge's concept of quality is affected by the combination of wines tested at one sitting, testing wine of one type provides more consistent results.

In a recent examination of the 20-point system, University researchers found that trained tasters required up to five years to consistently use the 20-point system, whereas scoring wines on a 9-point scale required less training. Although use of an overall rating scale will always be subject to slightly different use by different individuals and to the inevitable effect of one component (such as a dark color) on other components (such as oxidized aroma), use of the 20-point card with recorded comments has provided valuable information over the years.

Most recently, U.C. researchers have been using "profile" or "descriptive" scoring tests. Here, rather than assigning an overall quality rating to a wine, they rated the intensity of individual aroma attributes such as vegetative, woody, or fruity to characterize a series of commercial Cabernet Sauvignon wines. Similarly, in evaluating the effect of cropping level on Zinfandel wines, terms such as overall aroma or taste intensity were rated. In a study of the effect of oxidation by exposure to air, specific changes in wine flavor were measured by rating the intensity of fruity and oxidized flavors. This technique promises to provide very effective evaluation of wine treatments in the future.

In addition to developing systems for scoring wine, University researchers have contributed to an understanding and application of the basic principles of sensory evaluation. As early as 1939, recognizing the bias created by prior knowledge of a wine's identity, they advocated the use of coding or "blind" tasting procedures. In 1952, the basic principles of sensory evaluation needed to provide valid results were summarized. Observing the effect of distractions on panel performance, researchers recommended that wine scoring be performed in a quiet, odor-free, and isolated location. The effect of order of presentation in influencing the results similarly resulted in advice to present samples in a random but different order to each judge.

Since the 1950s, contributions from Davis researchers have helped to bring the food and wine industries and fairs from haphazard to controlled tastings. In a review of sensory practices