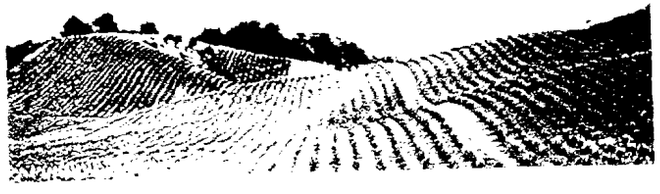
WINES
Their Sensory Evaluation



Maynard A. Amerine Edward B. Roessler
University of California, Davis

W. H. Freeman and Company
San Francisco

II
STATISTICAL PROCEDURES

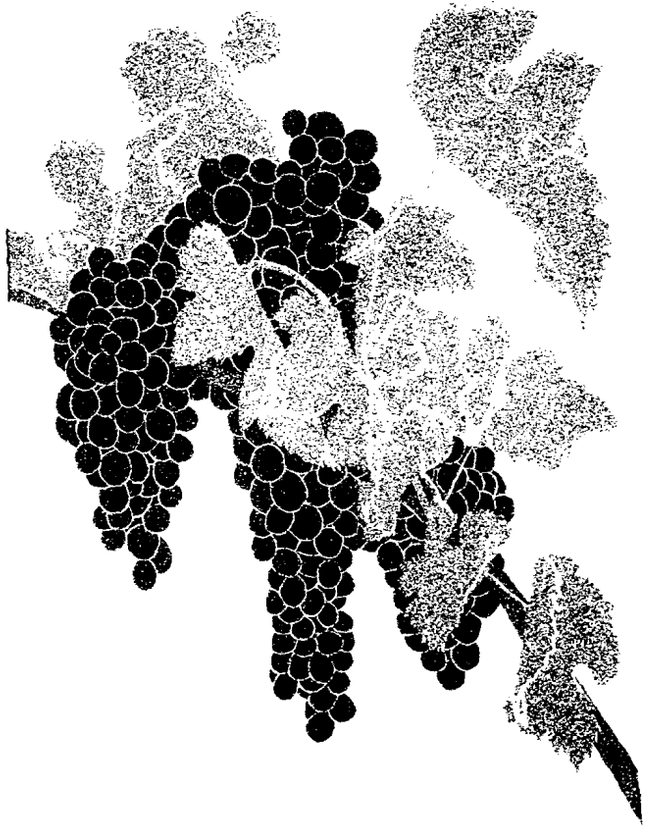


TABLE WINES

THE TECHNOLOGY OF THEIR PRODUCTION

M. A. AMERINE
& M. A. JOSLYN

SECOND EDITION

University of California Press
Berkeley and Los Angeles

CHAPTER EIGHTEEN

TASTING AND ANALYZING

Sensory and laboratory examinations must be made before bottling or shipping in bulk.

TASTING . . .

. . . is neglected in some wineries, but will yield valuable results if properly conducted.

Regular examination of the wines in the cellar by qualified wine tasters should be standard winery practice. By this means the wine maker can follow the development of the wine, detect incipient spoilage, establish the type and quality of the wine, prepare blends, and eventually decide upon the necessary treatment and blends as well as upon the time for bottling.

European enologists have generally been reluctant to use modern panel tests. (Ribéreau-Gayon and Peynaud, 1960–1961, 1964–1966; Flanzy, 1965). Nevertheless, many French regulations call for or imply some kind of sensory examination. Flanzy would have the sensory examination precede the chemical analysis and be a sort of guide to the type of analysis needed. He also noted, correctly, that in judging ordinary wines one must evaluate them as they are, but for high-quality wines one needs to take into account what they may become. The current interest in sensory evaluation of foods in France is indicated by a symposium on this subject held in Dijon, sponsored by the Institut Technique du Vin (1967). Some of the papers given at the symposium recognized the need for statistical analysis of the results, but others did not. One, at least, likened the taster presented with a fine wine as being like an explorer in a dark cave! (For a perceptive French symposium on the same subject see Anon., 1966c.) Amerine (1961) has emphasized the practical and legal aspects of sensory evaluation of alcoholic beverages. He believes that sensory tests made by standard procedures and using proper statistical analyses would be accepted by the courts. Even without this acceptance, they are useful where the quantities are small and the effect on quality is large. He indicated the need for better tests to distinguish the quality of wines from various regions, varieties, and processes. There is also a need for determination of the sensory threshold for many compounds and for evaluation of their interrelationships.

Troost (1965) stresses three objectives of sensory evaluation of wines: (1) the care of the wines at the winery, (2) quality evaluation, and (3), judging by governmental food agencies. For the first objective, chemical analysis should be used to supplement the sensory data. If qualified personnel and adequate laboratory data (particularly stability tests) are available, no difficult problems should arise. In the second objective, Troost (1965) noted the difficulty of comparing wines of different regions or seasons. He emphasizes the psychological factors which influence

Figure 118. Tasters at the California State Fair about 1937. From left to right: Charles Wetmore, Professors George L. Marsh, Maynard A. Joslyn, William V. Cruess, A. J. Winkler, and Maynard A. Amerine.

sensory panels, particularly information on source or price, where analytical data are of little value. Wines with the same analysis may have very different tastes and odors. But, as Troost said, quality and market success are not necessarily related. In the third objective (not often used in this country) the judges are asked to assess the relative merit of a group of wines in relation to normal conditions. Is the wine deserving of a *Spätlese*? Is the year a bad, good, or excellent one? Analytical data are useful in reaching a decision, particularly for abnormal wines. (See fig. 118 for an early post-Prohibition photograph of wine evaluation at the California State Fair.)

Jakob and Schrodt (1966) note that in storage experiments it is difficult to obtain absolute judgments of wine quality because of the changing quality of the samples during storage. They also found scoring to give more information than paired comparison tests. This is evidence of European consideration of the techniques recommended by Amerine *et al.* (1959*b*, 1965*a*).

Not all European enologists are averse to modern procedures of sensory evaluation of wine. Daepp (1966–1967) gives a critical and perceptive survey of the value of panel testing and a statistical evaluation of the results. For a list of terms see Vedel (1966). See also Joslyn and Amerine (1964) and Paul (1964). For a general survey of the sensory evaluation of foods see Amerine *et al.* (1965*a*) and A. D. Little (1958).

Ribéreau-Gayon (1964) and Peynaud (1965) had called attention to the effects of one component on the perceived sensations of others. Sugars weaken the acid taste, acids accentuate the bitter taste, and increasing volatile acidity (above 0.06 to 0.08 gr per 100 ml) decreases smoothness, as does ethyl acetate (above 150 mg per liter). For a more detailed study see Berg *et al.* (1955*a*, 1955*b*) and Hinreiner *et al.* (1955*a*, 1955*b*).

The influence of the environment on the results was studied by Foulonneau (1967). He investigated the influence of light, sound, interfering odors, and temperature. Since the results are discussed in subjective terms, without statistical analysis, it is difficult to evaluate them. However, some of the general results seem plausible or at least worth detailed experimentation. Reduction in light (i.e., cloudy), he believes, results in more agreeable odors in white and red wines compared to those under ordinary light. One finds it difficult to believe that pleasant music could change the reaction to odor if the judges were at all sophisticated. One would also like to have detailed information on the deformation of taste allegedly caused by smoking two cigarettes. The presence of butyric acid could, of course, have disagreeable effects on the judges. Foulonneau preferred 26°–27°C (78.8°–80.6°F) to 14°–15°C (57.2°–59°F) for tasting, and this seems reasonable.

Chemical analyses should be available when examining the tasting results, as they may confirm those results with regard to the soundness of the wine. Analyses may or may not confirm the tasting results.

Appearance

The first step in inspecting a wine is to examine its appearance (figs. 119, 120). This frequently establishes the condition of the wine. Often the nature of the sediment or cloudiness will indicate the specific, immediate treatment necessary. Various diseases have characteristic forms of clouding which the taster soon learns to recognize, particularly if working with a limited number of wines from a single source: for example, floating white particles indicate a film yeast infection; certain wines infected with *Lactobacillus* spp. have a silky cloudiness which is entirely distinct from ferric phosphate casse (see chap. 19).

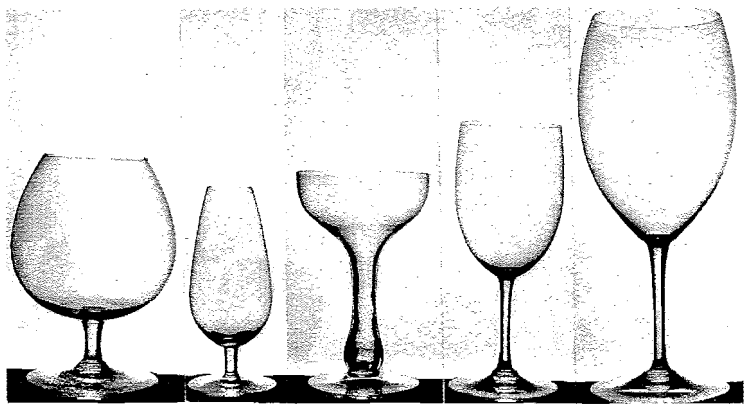


Figure 119. Glasses (left to right): first two for sensory evaluation of odor, for sparkling wines, last two for red or white wines.

The general appearance is usually classified as brilliant, clear, dull, or cloudy, according to increasing amounts of suspended material. Old wines that have been aged in the bottle have normal deposits of color and tannins, but the wine can be poured off in a brilliant condition, particularly if the bottle is not shaken when opened or is set on end a day or two before the cork is removed. This deposit is not, of course, a defect and is almost a guarantee of the age of the wine. However, on the highly competitive American wine market such a wine would encounter consumer resistance except from a limited clientele. Nephelometers are used to detect changes in appearance during filtration.

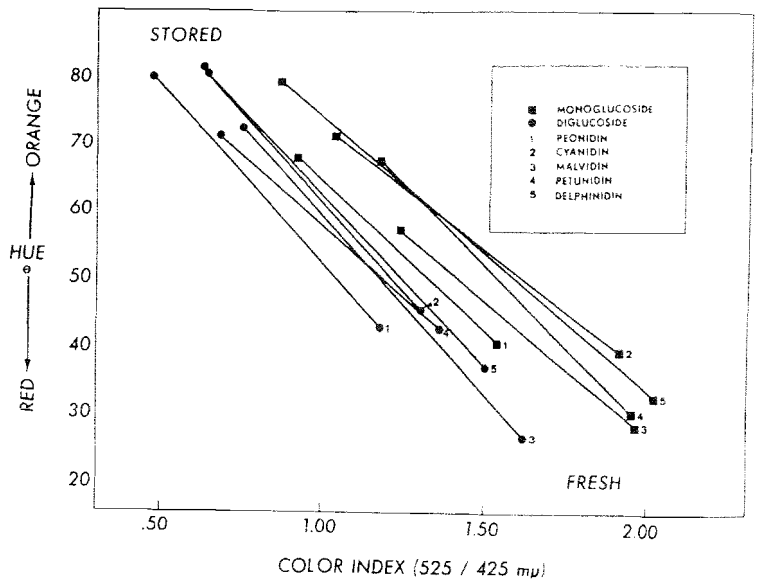


Figure 120. Relation of hue to color index (525–425 mμ ratio) for anthocyanin monoglucosides and diglucosides in wine before and after storage at 48.9° C (120° F). (From Robinson *et al.*, 1966.)

From the color, the taster can gain additional information. White wines that have become brown have usually been fermented on the skins too long, overaerated during cellar operations, or possibly overaged. Old white wines of good quality turn darker with age, but the color is more golden than brown. Old red table wines show a slight browning, quite characteristic and unobjectionable if not too pronounced. High-acid (or rather low-pH) wines always have an especially bright-red color not found in low-acid, high-pH wines. The first indications of the type of wine are given by the color. Light- and dark-colored types are quickly differentiated. Certain wines have distinctive tints, easily recognized. Where dyes have been added, these can sometimes be identified. Since many people "buy with their eyes," it is important to have a wine with an impeccable appearance. Each type should have a uniform and proper depth and shade of color.

White wines are usually graded from light yellow to gold, with green and amber as modifying tints. Red wines are marked as pink to deep red, with violet and brown the commonest modifying shades.

Odor

The difference thresholds for a number of odorous materials present in beers, as measured in beer, have been summarized by Harrison (1963). Difference thresholds in wine may be higher or lower, and research on olfactory thresholds of the volatile constituents of wine is urgently needed.

In order of difference sensitivity for a small laboratory panel these were: hydrogen sulfide (0.05), diacetyl (0.005), octaldehyde (0.001), ethyl isobutyrate (0.01), indole (0.1), linaloöl (0.1), methylnonyl ketone (0.1), caprylic acid (0.5), butyric acid (1), isobutyric acid (1), valeric acid (1), isovaleric acid (1), phenylacetic acid (1), butyraldehyde (1), isobutyraldehyde (1), ethyl propionate (1), isobutyl acetate (1), isoamyl acetate (1), acetal (1), 2-butanol (5), caproic acid (5), propionaldehyde (5), ethyl acetate (5), ethyl lactate (10), and acetaldehyde (25). The figures in parentheses are parts per 10^6. Other compounds, such as other acids and alcohols, had higher thresholds. Thresholds for 3-methyl-1-butanol in dry white wine varied from 100 to 900 mg per liter (average 300) for seven judges, according to Rankine (1967*a*). 2-Methyl-1-propanol and 1-propanol thresholds were over 500 mg per liter. The threshold for 3-methyl-1-butanol in water was 4 mg per liter. There is sufficient for certain judges to detect this alcohol. Differences in 2-methyl-1-propanol and 1-propanol in the range present in wines were not detected by seven panelists used. Kendall and Neilson (1966) showed that the odor of binary and quaternary mixtures cannot be predicted from those of the original components; synergistic, blending, and masking effects may occur.

Difference thresholds, mainly for taste components, in wine have been measured by Hinreiner *et al.* (1955*a*, 1955*b*) and Berg *et al.* (1955*a*, 1955*b*).

After careful visual inspection, the wine is smelled. Many diseases impart a characteristic odor or taste which is quickly recognized by the experienced judge. Wines with high volatile acid, hydrogen sulfide, sulfur dioxide, and the like can all be distinguished by smell alone. Other odors or tastes that indicate diseases or defects are mousy, moldy, corked, metallic, and bitter. If the odor indicates serious disease or defects, further testing is usually unnecessary.

Rankine (1966*b*) reported an off-flavor in Australian dry white table wine. The flavor was reported to be "yeasty, aldehydic". It was associated with growth of *Pichia membranaefaciens*. It grew in wine up to 11 per cent alcohol and did not tolerate any free sulfur dioxide. Acetaldehyde, ethyl acetate, isoamyl acetate, and an unidentified (but quantitatively important) compound were reported.

In California the "rubbery" off-odor described by Brown (1950) is associated with the fermentation of high pH musts. The origin of the

"earth" odor is not known, but it is definitely associated with grapes grown in certain regions (e.g., Davis, California).

The wine should not be sniffed continuously. Olfactory fatigue or insensitivity to the odor—even to a pronouncedly bad one—occurs very quickly. Thus a lesser quantity of the same spoilage product in the next wine tested may pass unnoticed.

Aroma refers to odors which are derived wholly or in part from the grape, such as Concord or muscat, and when recognized should be noted by the taster. A well-trained judge should be able to identify the aroma of the common varieties, such as Cabernet, Zinfandel, Sauvignon blanc, and Sémillon. Wines without a distinct aroma are marked as vinous. Bouquet is the aged odor characteristic of fine wines that have been aged in the bottle for one or more years.

Flavor

The actual tasting should be made with a very small quantity of liquid and only after the visual and olfactory examinations have been completed. By drawing air in and over this liquid in the mouth, the more elusive aromas are brought out. Sweetness, astringency, metallic flavors, and other taste qualities can be identified. The degree of smoothness of a red wine is frequently an indication of how long it must be aged before bottling. On the basis of the appearance, odor, and flavor, the taster must be able to evaluate the quality of the wine. Naturally this decision must conform to the type of wine being judged. The odor and flavor appropriate for one type of wine may not be so for another.

Münz (1963) notes that the acid taste of wines is due primarily to the acid salts, since most of the acids are partially neutralized. Wines in which an appreciable part of the acids are not bound to minerals are generally too acid in taste. Soluble salts seem to reduce the acid taste. The buffering capacity of musts and wines is expressed in terms of potassium equivalent: 1 gr per liter of potassium versus 0.31 gr of magnesium and 0.59 gr of sodium. Münz favors adjusting the acidity of musts in preference to that of wines. If the acid taste of wines needs to be adjusted (as it frequently does in Germany) he prefers to do this by blending.

As Münz (1965*a*) has indicated, the amount of must potassium is of critical importance to the acid taste of the resulting wine. This is due, obviously, to the reduction in acidity which occurs when large amounts of acid tartrate precipitate. He also notes that the mineral acids, sulfurous and phosphoric, have a hard acid taste. The free organic acids have a sharp acid taste, while their acid salts have a soft and delicate acid taste. Both the amounts of acid and the buffer capacity of the wine influence the

degree of acid taste. Münz added sulfuric acid and sulfuric and phosphoric acids together to wine. Sulfuric alone reduced the potassium content and increased the potassium sulfate content. Addition of both acids reduced the organic magnesium content and the potassium content, and increased the phosphate and sulfate contents. The original wine was slightly flat. Adding the acids decreased the buffer capacity and increased the hard acid taste. Münz considers that the organic bound potassium has only a buffer value, whereas the change of organic potassium from the organic to the inorganic form improves the fruity acid taste without changing the amounts of tartaric or malic acid. Munz (1967) has emphasized that the acid taste depends not only on the concentration of the acid but on its buffer capacity and on the effect of sugar and other compounds. The most important buffering is done by potassium, with lesser effects of calcium, magnesium, and sodium.

The relative sourness of malic, citric, tartaric, and lactic acids in wines was determined in two ways by Amerine *et al.* (1965). At the same titratable acidity the order of sourness was malic, tartaric, citric, and lactic. At the same pH the order was malic, lactic, citric, and tartaric. A noteworthy feature of this report was the relatively small differences in pH (0.05 pH unit) and titratable acidity (0.02 to 0.05 per cent) which could be detected by the panel. They concluded that both pH and titratable acidity were important in determining sensory response to sourness. In the study of Ough and Kunkee (1967) acid taste correlated well with the logarithm of the titratable acidity. However, in these studies quality and total acidity or pH were not well correlated—possibly because all the wines underwent a spontaneous malo-lactic fermentation.

The sweet taste has been extensively investigated in wines (see Amerine *et al.*, 1965*a*). Most California wineries now carefully control the sugar content of all the types of wines they produce. Amerine and Ough (1967) studied the sweetness preference for rosé wines of a group of twelve experienced judges. They found that six preferred drier types; five, sweeter types; and one had a broad range of acceptability. This bimodal type of distribution indicates that wineries may have to produce rosé wines with two levels of sugar in order to win maximum consumer acceptance. For interrelationships of taste see Pangborn *et al.* (1964) and Amerine *et al.* (1965*a*).

Comparing results with analyses

The tasting results should be compared with a chemical analysis of the wine. It is psychologically important that the taster not look at the analytical record before tasting. Accurate tasting may be used as a guide to the extent of chemical analysis necessary, and the two together act as the

rational basis for any treatments necessary for the wine. To gain confidence and skill, the taster should record his results and check them by a later, independent tasting.

Records and scoring

In spite of the wealth of information on how to conduct sensory examination of wines, Ough (1959*a*) reported very haphazard practices in the California wine industry. The fact that only 25 per cent of the California wineries answered his questionnaire would indicate widespread indifference to critical sensory examination of wine in the industry. Our experience is that this is true in Europe also.

Many tasters find it useful to keep a permanent record of their successive tastings for each wine. This is helpful in determining the duplicability of the taster's results and also in detecting desirable and undesirable changes in the wine during aging. To facilitate this record it is desirable to have some form of tasting card and to systematize the scoring. The suggested score cards shown below provide for a complete sensory examination of the wine. A more detailed subdivision of the score card may be made if desired. In using a score card it is important that the previously recorded data on a given wine should not be seen by the taster immediately before or during the scoring. This can be accomplished by covering the used portions of the card or by having the taster dictate his remarks to a secretary.

	Suggested number of points			
	Amerine et al. (1959b)	*Blaha (1951)*	*Cruess (1947)*	
Characters judged			*Dry white*	*Dry red*
Appearance	2	12	20	15
Color	2	12	10	10
Aroma and bouquet	4	12	10	15
Volatile acidity	2	—	15	15
Total acidity	2	—	10	10
Sugar	1	—	10	10
Body	1	12	—	—
Flavor	2	20	20	—
Tannin and astringency	2	—	10	10
General quality	2	12	—	15
Varietal character	—	20	—	—

Since many food products are judged on a percentage basis, it has been suggested that wines be so judged (Cruess, 1947). Although scoring systems from 0 to 100 are frequently proposed, it is difficult for inexperienced judges to distinguish a range of more than 10 to 15 grades, while 20 to 25 is about the usable range possible for experienced judges. Ough and Baker (1961) recommended a scale of 9 steps: average quality

with defects, 2–3 points; average, 4–6; above average 7–8; and superior, 9. (See Amerine, 1948*a*; 1948*b*; and Amerine *et al.*, 1959*b*, 1965*a*, for further information.) If a 100-point system is used, most wines will be found to fall in the range of 65 to 85.

The first scale of André *et al.* (1963) included 200 points! Later they presented three scales: one for red wines, one for rosé and white wines, and one for high-quality wines. The red wine scale was color 5, appearance 5, bouquet 10, bouquet (persistence) 10, taste-structure (balance?) 8, taste-softness 6, mouth-odor (after-taste?) 6, for a total of 50. The rosé and white wine scale was color 5, appearance 5, aroma 10, aroma (persistence) 10, fruitiness 8, freshness (acidity) 6, and elegance and harmony 6. For fine wines with expert panels they recommended the following scale: odor 30 (10 each for nature and number of components, richness and finesse of aroma, and identity of origin), taste 30 (10 for the basic tastes and 20 for the form of the wine, to include form of the structure, amplitude and mobility of taste sensations), mouth odor 20 (10 for the nature, finesse, and richness of the mouth odor and 10 for the persistence-taste plus odor), and total impression 20 (the relation between the sensations) for a total of 100.

We feel that panels would need considerable training to understand the proper use of these terms. We also question scales of 50 to 100 points. The scale of the Office International de la Vigne et du Vin (1961) of 20 points for table wines is acceptable, but the 5-point range for special wines seems too narrow.

Use of an anchor or reference sample improved performance in comparison with a straight score card in some tests but not in others, in the experiments of Baker *et al.* (1965*b*).

For determining the significance of differences in scores, Amerine *et al.* (1959*b*) recommended use of analysis of variance. The F-distribution provides an over-all test of significance among the different means. For determining the significance of the differences between means the multiple-range test is used. For specific instructions on these procedures see Amerine *et al.* (1959*b*, 1965*a*). An application of statistical analysis to sensory data has been made by Marie *et al.* (1962). Both complete and incomplete blocks were used.

Systems based on degree of like or dislike, called hedonic, have recently been used. A typical scale would be:

Like very much _____	Dislike slightly _____
Like much _____	Dislike much _____
Like slightly _____	Dislike very much _____
Neither like nor dislike _____	

An excellent example of the use of the hedonic system is the study of Huglin and Schwartz (1960) on grape juice. One advantage of hedonic systems is that they can be used with untrained judges. The hedonic scores are converted to figures and analyzed in the same way as the data from score cards.

Ranking methods are often useful for arranging a group of wines in the order of a specific characteristic. A series of wines might be arranged in the order of color, acidity, sweetness, or over-all quality. For tests to be meaningful, the judges must all be ranking on the same basis, that is, color in order of commercial acceptability, or quality based on experienced judges. Ranking gives no information on the degree of difference between any two wines. Paul (1967) praised rank-order as a method of distinguishing between wines, but had the wines separately ranked according to specific characteristics. Amerine and Ough (1967) found ranking and hedonic scoring gave essentially the same results in preference for sweetness in rosé wines. However, hedonic scoring appeared to give a larger scatter in results and a higher sugar preference. Ranking data can be evaluated statistically: either for the agreement in ranking between judges or as to how well a judge has ranked in comparison with some standard. For details and examples see Amerine *et al.* (1959*a*, 1965*b*).

Often the enologist is interested only in determining whether there is a difference between two wines. The difference may be due to processing, blending, aging, origin of grapes, fermentation procedures, or other factors. A number of techniques have been devised for such tests. Where the parameter of difference is known (sweetness, sourness, etc.) the paired test is favored. In this test the judge is given two samples and is asked, for example, which is sweeter, more sour, more muscaty. On the basis of the null hypothesis (that there is no difference between the wines), the probability of a taster identifying the sweeter wine by chance in each of several trials is 1 to 2. To determine the significance of the difference the χ^2 distribution is used. If N is the total number of tests (and N should be 7 or more) and X_1 the number of tests favorable to wine No. 1 and X_2 the number of tests favorable to wine No. 2, then

$$\chi^2 = \frac{([X_1 - X_2] - 1)^2}{N}$$

When the calculated value of χ^2 equals or exceeds 2.71, this indicates significance at the 5 per cent level ($p = 0.05$). In other words, this result would occur only once in twenty times by chance. If χ^2 is 5.40 or more, significance at the 1 per cent level, $p = 0.01$, is indicated; 9.55

or more, at the 0.1 per cent level, $p = 0.001$. These values are for identification of a known difference (a one-tailed test). The probabilities are also given in table 68.

TABLE 68

SIGNIFICANCE OF PAIRED TESTS ($p = \frac{1}{2}$)

No. of judges or judgments	*Minimum correct judgments to establish significant differentiation (one-tailed test)*			*Minimum agreeing judgments necessary to establish significant preference (two-tailed test)*		
	Probability level[a]					
	0.05	0.01	0.001	0.05	0.01	0.001
7	7	7	7	7	—	—
8	7	8	—	8	8	—
9	8	9	—	8	9	—
10	9	10	10	9	10	—
11	9	10	11	10	11	11
12	10	11	12	10	11	12
13	10	12	13	11	12	13
14	11	12	13	12	13	14
15	12	13	14	12	13	14
16	12	14	15	13	14	15
17	13	14	16	13	15	16
18	13	15	16	14	15	17
19	14	15	17	15	16	17
20	15	16	18	15	17	18
21	15	17	18	16	17	19
22	16	17	19	17	18	19
23	16	18	20	17	19	20
24	17	19	20	18	19	21
25	18	19	21	18	20	21
30	20	22	24	21	23	25
35	23	25	27	24	26	28
40	26	28	31	27	29	31
45	29	31	34	30	32	34
50	32	34	37	33	35	37
60	37	40	43	39	41	44
70	43	46	49	44	47	50
80	48	51	55	50	52	56
90	54	57	61	55	58	61
100	59	63	66	61	64	67

[a] $p = 0.05$ indicates that the odds are only 1 in 20 that this result is due to chance; $p = 0.01$ indicates a chance of only 1 in 100; and $p = 0.001$, 1 in 1000.
Source of data: Roessler *et al.* (1956).

If the nature of the difference between the two samples is not known, the duo-trio or triangular test is favored. In a duo-trio test three samples are presented. One is labeled as the reference sample and the other two are coded. One is the same as the reference and the other is different. The judge's decision then is concerned with which of the two coded samples is different from the reference sample. The analysis is exactly as for the paired test, or table 68 may be used.

If, in addition to identifying the different sample, the judge is asked which of the two he prefers, the test becomes a two-tailed procedure and the right-hand columns in table 68 are used for determining the significance.

In the triangular system three glasses are presented, two of which, however, contain the same wine and the other a different wine. The judge's problem is to identify which of the three glasses contains wine which is different from the other two. If the wines are A and B the wines could be poured in any of six orders: AAB, ABA, BAA, BBA, BAB, or ABB. The chance of identifying the odd sample correctly is $\frac{1}{3}$ ($p = \frac{1}{3}$) and the χ^2 value is

$$\frac{([4X_1 - 2X_2] - 3)^2}{8N}$$

N should be at least 5. The same values for significance apply as for the paired test. It is simpler to determine the significance by use of table 69.

It is difficult to state concisely the factors which constitute quality in table wines. Experienced enologists acquire a knowledge of those factors by constant testing of a wide variety of wines and by observing other tasters. All wines offered for sale should be free of such obvious defects as high volatile acidity, excessive sulfur dioxide, cloudiness, and inappropriate color. Wines of quality should also have a color and aroma appropriate to the type, a balanced and desirable flavor, and a pleasing aftertaste. The most common defect of California wines is their lack of a distinctive aroma or bouquet rather than the presence of any particular disease or defect.

Although the relation between chemical composition and quality cannot be completely stated because of our lack of information about the nature and quantity of many chemical substances which contribute to quality, some relations may be quantitatively stated. Volatile acidities of over 0.10 per cent, particularly in new wines, are very objectionable. (See p. 440.) A volatile neutral ester content of over 150 to 200 mg per liter as ethyl acetate is likewise undesirable. Red wines with a tannin content of over 0.20 per cent, or white wines with over 0.05 per cent, usually taste objectionably astringent. Table wines, particularly when new, will taste too alcoholic if the alcohol content is over 13 per cent, especially if the glycerin content is low—below 0.5 per cent.

The results of Filipello (1955, 1957*a*, 1957*b*), as summarized by Filipello and Berg (1959), demonstrated that experienced judges were significantly better than inexperienced judges in evaluating wine quality. However, use of a reference sample was essential for both groups. Filipello also preferred attitude rating scales to numerical scoring scales.

TABLE 69

SIGNIFICANCE OF TRIANGULAR TESTS ($p = \frac{1}{3}$)

No. of judges or judgements	Minimum correct judgments to establish significant differentiation			No. of judges or judgements	Minimum correct judgments to establish significant differentiation		
	$p = 0.05$	$p = 0.01$	$p = 0.001$		$p = 0.05$	$p = 0.01$	$p = 0.001$
5	4	5		56	25	28	31
6	5	6	6	57	26	28	31
7	5	6	7	58	26	29	31
8	6	7	8	59	27	29	32
9	6	7	8	60	27	30	32
10	7	8	9	61	27	30	33
11	7	8	10	62	28	30	33
12	8	9	10	63	28	31	34
13	8	9	11	64	29	31	34
14	9	10	11	65	29	32	34
15	9	10	12	66	29	32	35
16	9	11	12	67	30	32	35
17	10	11	13	68	30	33	36
18	10	12	13	69	30	33	36
19	11	12	14	70	31	34	37
20	11	13	14	71	31	34	37
21	12	13	15	72	32	34	37
22	12	14	15	73	32	35	38
23	12	14	16	74	32	35	38
24	13	14	16	75	33	36	39
25	13	15	17	76	33	36	39
26	14	15	17	77	33	36	39
27	14	16	18	78	34	37	40
28	14	16	18	79	34	37	40
29	15	17	19	80	35	38	41
30	15	17	19	81	35	38	41
31	16	17	20	82	35	38	42
32	16	18	20	83	36	39	42
33	16	18	21	84	36	39	42
34	17	19	21	85	36	39	43
35	17	19	21	86	37	40	43
36	18	20	22	87	37	40	44
37	18	20	22	88	38	41	44
38	18	20	23	89	38	41	44
39	19	21	23	90	38	41	45
40	19	21	24	91	39	42	45
41	20	22	24	92	39	42	46
42	20	22	25	93	40	43	46
43	20	23	25	94	40	43	46
44	21	23	25	95	40	43	47
45	21	23	26	96	41	44	47
46	22	24	26	97	41	44	48
47	22	24	27	98	41	45	48
48	22	25	27	99	42	45	49
49	23	25	28	100	42	46	49
50	23	25	28	200	79	83	88
51	24	26	28	300	114	120	126
52	24	26	29	400	150	155	164
53	24	27	29	500	185	192	200
54	25	27	30	1,000	359	369	381
55	25	27	30	2,000	702	717	733

Source of data: Roessler *et al.* (1948). However, a number of minor corrections have been made in the data by Roessler.

In tests at the California State Fair, Filipello (1957*a*) showed consumer preference for sweetened red table wines, for rosés of 1 to 3 per cent sugar over dry rosés, low-alcohol (7 to 8 per cent) muscatel, and Concord wines at a carbon dioxide pressure of 20 psi over still. Filipello and Berg (1959) found no significant preference for wines sweetened with sucrose, invert sugar, or grape concentrate. Even in a very large test 53 per cent preferred sucrose-sweetened wine as against 47 per cent otherwise sweetened. The State Fair audience was 56 per cent males, with 47 per cent in the

21–35 age group. As far as drinking wine was concerned, 34 per cent drank some several times a week, 41 per cent a few times a month, 21 per cent a few times a year, and 2 per cent never. Older participants preferred wines more than did younger participants. Filipello and Berg were able to show that the "infrequent" users had wine available in their homes. They implied that these did not become regular users of wine because they did not like the taste of conventional wine types. Therefore, they believed that wine sales could increase only by development of new types. Many attempts to do this since 1959 have not yet caused a significant rise in per capita wine consumption in this country.

COLOR AND PIGMENT EVALUATION . . .

. . . could be improved by the use of better equipment and more specific procedures.

The color of a wine is one of its most important attributes. Standardization of the color of each nonvintage wine is an important duty of the careful wine maker. Unfortunately, color specification is not simple. The perception of color involves a source of energy, an object, and an observer. With wines, it is the observer's concept of color which interests us. To specify a color completely it is necessary to measure three of its attributes: (1) dominant wave length, which corresponds to the hue; (2) purity, which refers to the degree of saturation of the color and is the attribute of a chromatic color which determines its degree of difference from the achromatic (gray) color of the same luminance; and (3) luminance (or brightness), which is related to the ratio of the amount of light leaving an object compared with that which is incident upon it. More specifically, luminance is the attribute of a color which classifies it as a member of a series of achromatic colors (that is, of gray colors ranging from black to white).

Methods available

To determine the dominant wave length, purity, and luminance of a wine, the spectrophotometer is commonly used, and a transmission curve is prepared for the visible spectrum. From this transmission curve the tristimulus values for red and green are then determined for a standard illuminant, using the methods of Hardy (1936). The luminance (brightness), obtained directly from the tristimulus values for yellow, is equal to the ratio of the sum of the tristimulus values for yellow actually determined divided by the sum of the theoretical values for 100 per cent brightness over the same range for the same standard illuminant. This is