Current Comments®

EUGENE GARFIELD
INSTITUTE FOR SCIENTIFIC INFORMATION®
3501 MARKET ST., PHILADELPHIA, PA 19104

Enology. Part 2. How Modern Research Uncorks the Secrets of Wine: UC Davis and Bordeaux's Enology Institute Lead the Way

Number 30 July 27, 1987

References to wine appear in the oldest written sources, suggesting that "appreciation of wine is as ancient as civilization," as noted by organic chemist Philip Jackisch, a consultant to the wine industry.[1] Grape harvesting is depicted on the walls of the tombs of ancient Egyptian pharaohs.[2] (p. 13) References to wine as a gift or as the elixir of the gods—and sometimes as the blood of the gods[3] (p. 14-31)—can be found in the Sumerian epic of *Gilgamesh*[4] and in the mythologies of the ancient Babylonians, Greeks, and Romans.[2] (p. 9) For instance, in the oldest of Western epics, Homer's *Iliad*[5] and *Odyssey*,[6] the Mediterranean is described as the "wine-dark" or "wine-faced" sea. And since wine was used as a libation, or offering, to the gods in rituals, depictions of these ceremonies are among the earliest examples of art associated with wine.[2] (p. 12) Indeed, the symbolic purpose of wine in religious ceremonies is still with us, as in the Jewish ceremony of kiddush, a ceremonial blessing pronounced over wine or bread,[7] and in the Christian sacrament of the Eucharist,[2] (p. 47) in which bread and wine are used in commemorating the death of Christ.[8]

Of course, references to wine in art and religion are not confined to antiquity. Views of vineyards and representations of wine making and wine drinking occur in many cultures from virtually all time periods and in such diverse media as sculpture, illuminated manuscripts, woodcuts and engravings, tapestries, frescoes, glass- and earthenware, and paintings and photographs.[2] In the first part of this essay, we noted that the millennia-old art of wine making has largely given way to the science of enology, and we gave a brief overview of the current areas of scientific interest.[9] This second part discusses the evolution of scholarly interest in wine making and describes some of the centers of wine research. But we should not forget that while industrial wine making has increased, the proliferation of small vineyards has also taken place. Oddly enough, a significant number of the prizewinning wines at international exhibitions each year come from countries and places not ordinarily associated with distinguished wines.[10]

Origins of Wine and Wine Making

Since the Old World wine grape *Vitis vinifera* (known as *Vitis sylvestris* in its wild form) is native to the temperate region of the Mediterranean basin, it is likely that grape wine originated in Asia Minor.[2] (p. 12) [11] An ancient Persian myth attributes the invention of wine to the legendary King Jamsheed. According to the legend, some jars containing grapes (stored for out-of-season consumption) gave off a strange aroma when opened; the jars were consequently labeled poisonous. One of the ladies of Jamsheed's court attempted to commit suicide by drinking the "poison" and discovered that it cured her depression in a manner wholly different (if less permanent) than she had imagined. The king was informed and, upon tasting the "poison" himself, approved it for use by his subjects.[2] (p. 9) But the lineage of wine is far older than this story would indicate; as Dan Stanislawski, professor emeritus of geography, University of Arizona, Tucson, says,[12] evidence of rudimentary wine mak-

ing has been found that dates back to the Neolithic period.[13]

The Old World Wine Industry

Although the production of wine has a long heritage, it wasn't until 1857, when Louis Pasteur published his "Report on alcoholic fermentation,"[14] that the main process in creating wine—and the means of controlling it—began to be understood.[15] Until Pasteur's discovery that it is living yeast cells that convert grape sugar into alcohol and carbon dioxide, the art of wine making had remained essentially unchanged for thousands of years.[16] Winegrowers picked grapes by hand and crushed them by foot, then allowed the juice to ferment by the yeasts that grow naturally on grape skins. Solids and sediments were removed by allowing them to settle to the bottoms of barrels and bottles while the clear wine was drawn off the top. Innovations consisted largely of small adjustments to technique, such as varying the kind of wood used for the barrels, or mixing two or more kinds of grapes. Indeed, some wineries still operate in the time-honored traditions handed down for generations.

Pasteur's work opened the door to methodical research into the various aspects of wine making, but it was the plant louse *Phylloxera vastatrix*, which devastated vineyards in both Europe and California from 1860 to 1900, that was responsible for the first truly intensive work in the field of viticultural and enological research. *Phylloxera* was inadvertently exported to Europe from the eastern US, along with vines native to North America.[17] The louse "defied any chemical control," according to H.P. Olmo, Department of Viticulture and Enology, University of California, Davis,[17] and by the late 1880s at least one-third of French vineyards had been destroyed, with comparable losses in the vineyards of other European nations. The fragile *Vitis vinifera* vine had little resistance to the insatiable hunger of *Phylloxera*, prompting the French government to undertake a study of American vines for those that were most resistant to the depredations of *Phylloxera*. Stems of *vinifera* were successfully grafted onto the roots of some of these; thus, as Olmo notes, "what were once individual vines became... two-story component[s]."[17]

The University of Bordeaux

It was during this plague of plant lice that the Institute of Enology at the University of Bordeaux was established (1880), under the direction of Ulysse Gayon, who was assistant to Pasteur at the Ecole Normale Supérieure, Paris.[18] Interestingly, the directorship of the institute has remained in the Gayon family ever since. Ulysse's grandson, Jean Ribéreau-Gayon, assumed the post in 1949; his great-grandson, Pascal Ribéreau-Gayon, followed the tradition in 1977.[19] Under the direction of Jean Ribéreau-Gayon, the institute revised its academic curriculum; in 1955, it established a two-year degree program for a National Diploma of Enology. The program currently accepts approximately 200 students a year (of whom 15 to 20 percent are foreign). According to science writer Janis Lasky-Couvreux, the institute's research began to have a noticeable impact on French wine making in the 1960s, when vintners began to apply the institute's results in their work.[19] Today, institute researchers work closely with the French wine industry. It is a rare vintner in France who does not employ or at least consult an enologist (often one trained at Bordeaux); in fact, many vintners now have some enological training themselves.

Among the highly cited works by researchers affiliated with Bordeaux is a monograph entitled *Plant Phenolics*, by the current director, Pascal Ribéreau-Gayon.[20,21] Published in 1968 in French[20] and in 1972 in English,[21] it has been cited in at least 200 publications—over half to its English version. The book describes the botanical chemistry of phenols, which, as mentioned in Part 1,[9] occur in numerous foods and beverages and, in wine, are responsible for some of the quality, storage, and flavor characteristics of the final product.

In addition, for the past 40 years various editions of a treatise on enology have been written by workers at Bordeaux and published by Dunod in Paris.[18] The latest edition, entitled *Sciences et Techniques du Vin*, was written by Jean Ribéreau-Gayon, Emile

Peynaud, Pascal Ribéreau-Gayon, and Pierre Sudraud.[22] It includes four volumes that have been translated into Spanish, Italian, and Russian. Jean Ribéreau-Gayon and Peynaud have also authored numerous works since 1950 on malolactic fermentation in red wines.[18] This process is, in effect, a "second fermentation" (following the primary one in which sugar is converted into ethanol). In malolactic fermentation, malic acid breaks down into the milder lactic acid and carbon dioxide; wine bottled before malolactic fermentation has occurred will smell like green apples and will be spoiled by the release of the carbon dioxide.[15]

The University of California, Davis

Humanity sometimes seems unable to learn without disaster; later generations, however, may benefit. The *Phylloxera* louse catastrophe probably gave the impetus to formalized wine research. It is not a mere coincidence that, in the US, wine research also began in 1880, with the establishment of the Department of Viticulture and Enology at the University of California by an act of the state legislature.[23] (p. 30) Indeed, one of the first tasks of the botanists at the university was to find a solution to the problem posed by *Phylloxera*.[24] Vineyards in California, like those in Europe, were (and still are) planted almost exclusively with the Old World *vinifera* grapevine, and, as in Europe, from 1860 to 1900 *Phylloxera* devastated these vineyards.[23] (p. 22) [24] Like their counterparts in France, workers at the university grafted *vinifera* stems onto the roots of resistant North American vines already growing in the ground; they thereby "saved the California wine industry," according to science writer Charles Martin.[24]

Prohibition

The US wine industry recovered from the *Phylloxera* plague just in time to face a new trial—Prohibition, a period from 1919 to 1933 when the manufacture, sale, and transportation of alcoholic beverages was made illegal by the passage of the Eighteenth Amendment to the US Constitution.[25] Surprisingly, vineyards actually prospered during the first years of Prohibition as a sudden demand for grapes—used in home fermenting, which, up to a point, was permitted during Prohibition—sent prices soaring from $10 a ton to the unheard-of figure of $100 per ton.[23] (p. 23) But the prosperity lasted only from 1920 through 1925; the market for grapes collapsed when refrigerated railroad cars became common and growers shipped so many grapes that they rotted in the terminals, "waiting for buyers who already had enough," according to wine writer Leon D. Adams.[23] (p. 24) By the end of the Prohibition era—occasioned by the passage of the Twenty-First Amendment, which repealed the Eighteenth[25]—the US vineyards were in both physical and financial ruins.[23] (p. 27)

But the University of California again aided the US wine industry, providing trained wine makers to staff vineyards and cellars as the wine industry struggled to regain its pre-Prohibition strength. According to Adams, the university had continued its basic research on fruit processing and nonalcoholic grape drinks during Prohibition "under the innocent title of 'the fruit products laboratory.' "[23] (p. 30) Following the repeal of the law, the university immediately launched new programs in wine research and grape breeding and took over a neglected government vineyard in the famed winemaking region of the Napa Valley. It also established an experimental winery and brandy distillery at a university farm at its Davis campus, where it developed new courses in vineyard and winery operation.[23] (p. 30-1)

For many years the only US institution granting a four-year undergraduate degree or graduate training (including MS and PhD degrees) in enology or viticulture was the Department of Viticulture and Enology at the Davis campus of the University of California. Today, Davis remains one of the few such institutions in the world, but it has been joined by such institutions as Cornell University, Ithaca, New York; California State University, Fresno; Michigan State University, East Lansing; Mississippi State University, Mississippi State; Ohio State University, Columbus; and Pennsylvania State University, University Park.[26] Although some of the degree programs may be called by various names—such as food science, fermentation science, plant science, or horti-

Table 1: Selected list of institutions worldwide conducting research on enology and viticulture. List is arranged alphabetically by country.

AUSTRALIA
Australian Wine Research Institute
Private Mail Bag
Glen Osmond
South Australia 5064

Commonwealth Scientific and Industrial Research Organization
Division of Horticultural Research
Private Mail Bag
Merbein, Victoria 3505

BULGARIA
Institute of Viticulture and Enology
Pleven

FEDERAL REPUBLIC OF GERMANY
Johannes Gutenberg University of Mainz
Microbiology and Winemaking Institute
Saarstrasse 21
D-6500 Mainz

Research Station for Viticulture, Horticulture, Beverage Technology, and Landscape Development
von Lade-Strasse 1
Geisenheim

FRANCE
French Technical Institute of Viticulture and Oenology
21 rue Francois 1er
75008 Paris

Institute of Enology
University of Bordeaux
351, cours de la Liberation
33405 Talence Cedex

HUNGARY
Research Institute for Viticulture and Oenology
Kisfai 182
H-6000 Kecskemet

ISRAEL
Israel Wine Institute
POB 2329
4 Ha-Raz Street
Rehovot 76310

ITALY
Enology Experimental Research Institute
Chemistry Enology Section
Via Pietro Micca, 35
14100 Asti

Oenology Institute
Catholic University of the Sacred Heart
Via Emilia Parmense 84
29100 Piacenze

Viticulture and Oenology Research Center
Bologna University
Via Zamboni 33
40126 Bologna

Viticulture Experimental Research Institute
Via XXVIII Aprile No 26
Conegliano

JAPAN
Institute of Oenology and Viticulture
Yamanashi University
Kofo
Yamanashi 400

culture[26,27]—these schools are "definitely turning out wine makers and grape growers," according to Jackisch.[26]

One of the highly cited works by researchers affiliated with the Department of Viticulture and Enology at Davis is a 1965 monograph by Maynard A. Amerine, Rose Marie Pangborn, and Edward B. Roessler entitled *Principles of Sensory Evaluation of Food*.[28] It has been cited about 350 times, according to data from the *Science Citation Index®*. Together with Cornelius S. Ough, professor of enology and chairman, Department of Viticulture and Enology at Davis, Amerine wrote another highly cited work—a book entitled *Wine and Must Analysis*.[29] ("Must" is the term for the juice of crushed grapes.) The book has been cited in over 80 publications since it appeared in 1974.

Another work by Davis researchers is the book *Phenolic Substances in Grapes and Wine, and Their Significance*.[30] One of the core items discussed in Part 1,[9] it was written by Vernon L. Singleton and Paul Esau and has been cited over 60 times since 1969. Together with Joseph A. Rossi, Singleton is also the author of the most-cited paper from the *American Journal of Enology and Viticulture* (*AJEV*).[31] Cited over 150 times since its publication in 1965, the paper discusses an improved method of analysis that is applicable to a number of different foods and beverages that are derived from plants.

Singleton's *Citation Classic®* commentary was published in 1985 in *Current Contents® /Agriculture, Biology & Environmental Sciences*;[32] in it, he stated that in 1965 it had become "increasingly clear that the

NEW ZEALAND
Department of Scientific and Industrial Research
P.O. Box 19
Te Kauwhata

PEOPLE'S REPUBLIC OF CHINA
Beijing Agricultural University
Department of Horticulture
Beijing

PORTUGAL
Port Wine Institute
Rua de Ferreira Borges
4000 Porto

REPUBLIC OF SOUTH AFRICA
Viticultural and Oenological Research Institute
Nietvoorby
Private Bag X5026
Stellenbosch 7600

ROMANIA
Vine-Growing and Wine-Making Research Institute
2040 Valea Calugareasca
Prahova

SWITZERLAND
Swiss Federal Research Station for Fruit-Growing, Viticulture and Horticulture
CH-8820 Wadenswil

USSR
All-Union Research Institute of Winegrowing and Wine Production
Arsenalmaya ploshchad 15
Novocherkassk

US
Department of Enology, Food Science and Nutrition
California State University
Fresno, CA 93740

New York State Agricultural Experiment Station
Cornell University
P.O. Box 462
Geneva, NY 14456

Department of Viticulture and Enology
University of California
Davis, CA 95616

YUGOSLAVIA
Institute for the Advancement of Viticulture of Macedonia
Naselba Butel 1
91000 Skopje

amount and specific mixture of natural phenols are crucial to characteristics, quality, and storage reactions of different wines and other foods and beverages from plants. A predictable method for total phenol analysis was essential." Singleton and Rossi, a graduate student at the time, made several improvements to an existing method, and Singleton says the new method is particularly useful for analyzing dry red wines.[32]

Other Centers of Enology

Table 1 lists a number of major research institutions in the field of wine and wine making. This selective list is by no means exhaustive. Moreover, much important enological research is performed by workers in other disciplines, such as horticulture, microbiology, and plant sciences. And in addition to research institutions, there are numerous organizations around the world that provide information on the technical and commercial aspects of wine and wine making. These are listed in Table 2.

Enology Journals

In 1950 the American Society for Enology and Viticulture (which, until 1983, was called the American Society of Enologists), founded *AJEV*. Published quarterly, *AJEV* is edited by JoAnne M. Rantz and is one of a number of enological journals indexed by ISI®. Table 3 lists these and their impact factors, as well as several journals not indexed by ISI. But as we noted above, many disciplines contribute to enology research, and pertinent papers are published in journals other than those devoted strictly to enology. For instance, *Experientia*, an interdisciplinary journal for the life sciences, published what it called a "multi-author review" of enology research in 1986.[33] In fact, *AJEV*—perhaps the major wine journal in Table 3—cites and is cited by a number of journals outside of what might be thought of as a core of wine journals (those dedicated to viticultural and enological research). According to data from the *Journal Citation Reports®*, *AJEV* is frequently and understandably cited by such journals

Table 2: Selected list of organizations and societies providing information on technical and commercial aspects of wines and wine making.

American Society for Enology and Viticulture
P.O. Box 1855
Davis, CA 95617

American Wine Association
Ten East 40th Street, Room 2000
New York, NY 10016

American Wine Society
3006 Latta Road
Rochester, NY 14612

Brotherhood of the Knights of the Vine
P.O. Box 13285
Sacramento, CA 95813

The English Vineyards Association Ltd.
The English Wine Centre
Drusillas Corner
Alfriston, East Sussex BN26 5QS
United Kingdom

International Union of Oenologists
14 rue Etienne Pallu
F-37033 Tours Cedex
France

Les Amis du Vin
2302 Perkins Place
Silver Spring, MD 20910

International Vine and Wine Office
11 rue Roquepine
F-75008 Paris
France

Society of Medical Friends of Wine
Box 218
Sausalito, CA 94965

Wine Institute
165 Post Street
San Francisco, CA 94108

Table 3: *Selected list of publications reporting on* enology and viticulture. A=title. B=1985 impact factor.

A	B
American Journal of Enology and Viticulture	0.45
Applied Microbiology and Biotechnology	1.51
Bulletin de l'Office International de la Vigne et du Vin	—
Connaissance de la Vigne et du Vin	—
Hakkokogaku Kaishi—Journal of the Society of Fermentation Technology	0.11
Hortscience	0.51
Journal of Food Science	0.92
Journal of the American Society for Horticultural Science	0.71
Journal of the Science of Food and Agriculture	1.00
Lebensmittel—Wissenschaft—Technologie	0.59
Plant Physiology	3.12
Schweizerische Zeitschrift fur Obst und Weinbau	—
Vinodelie i Vinogradarstvo SSSR	—
Vitis	0.52
Weinwirtschaft/German Wine Review	—

as the *Journal of Food Science* and *Crop Science* and cites such journals as *Advanced Food Research* and *Plant Physiology*.

The Mystique of Wine

Wine is a significant agricultural product in many nations. According to 1985 figures, Italy leads the world in wine production, averaging about 2 billion gallons per year; France is close behind at 1.7 billion gallons per year. Other leading wine producers include Spain (900 million gallons), the USSR (820 million), Argentina (620 million), the US (435 million), Portugal (250 million), Rumania and Yugoslavia (200 million each), and the Federal Republic of Germany (190 million).[23] (p. 1)

But the importance of wine goes far beyond economic statistics. Throughout much of the wine-drinking world, wine is an everyday beverage that is most often consumed during the course of an ordinary meal.[23] (p. 13) In the US, owing to a variety of factors—some cultural, some historical—wine has been considered by many as appropriate only for sophisticates or for special occasions.[23] (p. 5-14) [34,35] Unfortunately, this mystique may discourage many potential wine drinkers who might otherwise enjoy the conviviality of a good meal complemented by a good wine.

A large factor in the mystique of wine has been the rituals and attitudes that have surrounded the production and serving of wine. While some find these rituals enchanting or

romantic, others find them baffling or even intimidating. Yet most of these rituals are rooted in commonsense practice intended to enhance the enjoyment of wine.

Wine-Serving Rituals

For instance, according to John Mariani, wine writer for the now-defunct *Cuisine* magazine, some wine is aerated in advance of serving because "exposure of a wine to oxygen helps develop the bouquet, bring out the fruit, soften the tannin, and dispel pent-up staleness."[35] However, Mariani cautions that merely uncorking the wine bottle will not allow oxygen to come in contact with enough of the wine to have any effect; proper aeration involves decanting the wine into glasses, to be swirled for a few minutes before sipping. Moreover, he points out that most white wines need no aeration at all and that some may actually be slightly oxidized if exposed to the air too long. In fact, although aeration may benefit some older, vintage red wines, Mariani notes that it is unnecessary with red table wines.[35]

The practice of serving and storing wine bottles on their sides is another example of a practice that seems mysterious until its roots are explained. Although some table wines today have airtight caps made of metal or plastic, in the past most wines were sealed with cork (as many still are, of course). Cork, however, dries out and contracts upon exposure to air, and an ill-fitting cork will admit air to a bottle of wine. Over a sufficient period of time, this air will oxidize the wine, making it turn brown and taste "dried out, like dead leaves," in the words of *New York Times Magazine* wine writer Frank J. Prial.[36] Storing the wine on its side keeps the liquid in the bottle in contact with the cork, preventing the cork from drying out. Another reason for storing and serving wine on its side was to avoid disturbing the layer of sediment that collected at the bottom of the bottle.[35] Most modern wines, however, have the sediment filtered out during processing.

The wine-serving rituals of trained wine stewards (called sommeliers) in fine restaurants are also part of the wine mystique. Diners sometimes avoid ordering wine in such restaurants because they are afraid the sommelier will expose their ignorance of wine. But Mariani says sommeliers "are professionals whose job it is to know the establishment's wines...and to serve precisely what pleases" the customer.[35] They can recommend a wine appropriate for a given food or even recommend a different wine for each course. As Prial writes, "Ordering a wine in a restaurant should be a cooperative venture.... A serious restaurant has people who look forward to helping you pick a bottle you will enjoy. Ask for help."[36]

US Interest in Wine Grows

Wine is not part of the ordinary meals of most people in the US (nor, for that matter, in many other countries—including the Moslem world, where the consumption of alcohol is prohibited), and per capita wine consumption in the US trails the rest of the wine-drinking world. Although annual US per capita consumption is on the rise and, as of 1981, stood at about 2 gallons,[37] consumption in France, for instance, was about 23 gallons for the same year. The 1981 figures for Portugal, Italy, Argentina, and Spain—the four countries immediately behind France in consumption—were about 20, 19.5, 19, and 16 gallons, respectively; UK consumption was comparable to that of the US, at 2 gallons.[37] Incidentally, while consumption figures are given in gallons, most wine is purchased by the liter, owing to the conversion to metric measurement in the wine industry.

But as I mentioned in Part 1,[9] interest in wine is increasing throughout the US. Numerous magazines devoted to the interests of wine enthusiasts—such as *Vintage Magazine* and the *Wine Spectator*—are being published, while other magazines, such as *Gourmet*, have regular features on wine. In addition, over 200 daily newspapers now carry regular wine columns. More than 450 new wineries opened across the nation in 1985 alone—42 of them in states where no wines from locally grown grapes had been produced since the nineteenth century, such as Alabama, Arizona, Connecticut, Florida,

Georgia, Idaho, Mississippi, Tennessee, and Virginia.[23] (p. ix) And in 1980, for the first time in US history, per capita wine consumption exceeded that of distilled spirits.[23] (p. x) Perhaps US wine drinkers are beginning to discover what Charles Seltman, University of Cambridge, UK, so aptly expressed in his book *Wine in the Ancient World*:

> Tea may be a boon, tomato juice a medicine, but we need the grape for joy. Much may be done with spirits, and good beer is good food; but it is wine that maketh glad the heart of man.[3] (p. 14)

All Good Things in Moderation

On that last point, may I remind readers of our essay on the beneficial effects of drinking wine in moderation—particularly its benefits for the cardiovascular system.[38] As we said then, there is some evidence that moderate wine drinkers have fewer cardiac problems and thereby live a bit longer than either nondrinkers or alcoholics.[39] A strong, negative correlation between wine consumption and ischemic heart disease—in which heart tissue dies from lack of blood, due to clogged cardiac vessels—was found by A.S. St. Leger and colleagues of the UK's Medical Research Council. In their conclusion, they added that "if wine is ever found to contain a constituent protective against ischaemic heart disease, then we would consider it almost a sacrilege that this constituent should be isolated. The medicine is already in a highly palatable form."[39]

Readers may also recall our review of duodenal ulcers, in which we noted that there is some dispute about whether alcohol can be tolerated by ulcer patients.[40] From my own experience, I can say that even the gentlest wine, being slightly acidic, caused me no end of grief. But since surgery removed me from the ranks of those enslaved by cyclical ulcer attacks, I am able to enjoy my Piesporter Goldtröpfchen[9] without fear of reprisal.

The ability to tolerate wine may be genetic or it may be a matter of culture and upbringing, like a taste for chili peppers. While I can remember my grandfather stamping red Concord grapes in the bathtub, the resulting wine was used only on holidays. As Europeans know, most Americans grow up drinking far more milk than wine (although Americans' consumption of beer, usually beginning in the teen years, is not trivial). In the past generation it seems that the consumption of wine with meals has increased significantly, but this has not yet had the effect of displacing milk. Any decrease in the use of milk products, such as ice cream, is probably due to weight and health considerations.[41]

Although this two-part essay has been devoted primarily to identifying areas of wine-making research, I can't resist mentioning wine tasting, which has become so popular of late in the US. In fact, wine-tasting parties are a feature of the annual molecular biology symposia at the University of Miami, Florida. At these events, organized by Professor Bill Whelan, editor of the *FASEB Journal* (formerly *Federation Proceedings*), each exhibitor serves a different wine; guests wander from kiosk to kiosk, tasting the many varieties. Between each taste they are supposed to eat a small piece of bread or cracker to properly prepare their taste buds for the next sip. It is a surprise to realize that even the untrained palate can detect both small and large differences in flavor. And the party is not just idle socializing: after a dozen or so wines, you may find yourself more receptive to new ideas. I know of no formal research that will prove that wine increases your research output, but I imagine some reader will soon let me know the impact of lowered stress on the creative process.

* * * * *

My thanks to Stephen A. Bonaduce and C.J. Fiscus for their help in the preparation of this essay.

REFERENCES

1. **Jackisch P.** *Modern winemaking.* Ithaca, NY: Cornell University Press, 1985. p. 17.
2. **Johnson H, Janson D J & McFadden D R.** *Wine: celebration and ceremony.* New York: Cooper-Hewitt Museum, 1985. 127 p.
3. **Seltman C.** *Wine in the ancient world.* London: Routledge & Kegan Paul, 1957. 196 p.
4. *Gilgamesh.* (Gardner J & Maier J, trans.) New York: Knopf, 1984. 304 p.
5. **Homer.** *The Iliad of Homer.* (Lattimore R, trans.) Chicago, IL: University of Chicago Press, 1951. 527 p.
6. ----------. *The Odyssey of Homer.* (Cook A, trans.) New York: W.W. Norton, 1974. 516 p.
7. Kiddush. (Mish F C, ed.) *Webster's ninth new collegiate dictionary.* Springfield, MA: Merriam-Webster, 1985. p. 660.
8. Communion. (Mish F C, ed.) *Webster's ninth new collegiate dictionary.* Springfield, MA: Merriam-Webster, 1985. p. 266.
9. **Garfield E.** Enology. Part 1. Fortifying an ancient art with modern science. *Current Contents* (29):3-8, 20 July 1987.
10. **Seldon P,** ed. Award winning wines. (Whole issue.) *Vintage Mag.* 13(1), 1984. 70 p.
11. Viticulture. *Encyclopaedia Britannica.* Chicago, IL: Encyclopaedia Britannica, 1985. Vol. 12. p. 404.
12. **Stanislawski D.** Dionysus westward: early religion and the economic geography of wine. *Geogr. Rev.* 65:427-44, 1975.
13. **Helbaek H.** The paleoethnobotany of the Near East and Europe. (Braidwood R J & Howe B, eds.) *Prehistoric investigations in Iraqui Kurdistan.* Chicago, IL: University of Chicago Press, 1960. p. 99-118.
14. **Pasteur L.** Chimie organique. Mémoire sur la fermentation appelée lactique (Organic chemistry. Report on alcoholic fermentation). *C. R. Acad. Sci.* 45:913-6, 1857.
15. **Bass T A.** The new French revolution. *Sci. Digest* 94(1):61-7; 84-5, 1986.
16. **Weinrib J M.** Winemaking: acquiring a taste for technology. *Mech. Eng.* 108(9):46-57, 1986.
17. **Olmo H P.** The potential role of (*vinifera* × *rotundifolia*) hybrids in grape variety improvement. *Experientia* 42:921-6, 1986.
18. **Ribéreau-Gayon P.** Personal communication. 15 June 1987.
19. **Lasky-Couvreux J.** The Institute of Enology in Bordeaux. *Vintage Mag.* 9(10/11):88-91, 1980.
20. **Ribéreau-Gayon P.** *Les composés phénoliques des végétaux* (Plant phenolics). Paris: Dunod, 1968.
21. ----------. *Plant phenolics.* New York: Hafner, 1972. 254 p.
22. **Ribéreau-Gayon J, Peynaud E, Ribéreau-Gayon P & Sudraud P.** *Sciences et techniques du vin* (Science and techniques of wine). Paris: Dunod, 1972. 4 vols.
23. **Adams L D.** *The wines of America.* New York: McGraw-Hill, 1985. 608 p.
24. **Martin C.** High-tech winemaking. *Discover* 4(3):86-8, 1983.
25. Prohibition. *Encyclopaedia Britannica.* Chicago, IL: Encyclopaedia Britannica, 1985. Vol. 9. p. 722-3.
26. **Jackisch P.** Personal communication. 7 June 1987.
27. **Singleton V L.** Personal communication. 8 June 1987.
28. **Amerine M A, Pangborn R M & Roessler E B.** *Principles of sensory evaluation of food.* New York: Academic Press, 1965. 602 p.
29. **Amerine M A & Ough C S.** *Wine and must analysis.* New York: Wiley, 1974. 121 p.
30. **Singleton V L & Esau P.** *Phenolic substances in grapes and wine, and their significance.* New York: Academic Press, 1969. 282 p.
31. **Singleton V L & Rossi J A.** Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *Amer. J. Enol. Viticult.* 16:144-58, 1965.
32. **Singleton V L.** Citation Classic. Commentary on *Amer. J. Enol. Viticult.* 16:144-58, 1965. *Current Contents/Agriculture, Biology & Environmental Sciences* 16(48):18, 2 December 1985.
33. **Ribéreau-Gayon P,** ed. New progress in vine and wine research. *Experientia* 42:857-941, 1986.
34. **Buchen V.** Folkloric origins of wine rituals. *Vintage Mag.* 7(2):20; 57, 1977.
35. **Mariani J.** Examining the myths about wine. *Cuisine* 11(5):16; 18; 103, 1982.
36. **Prial F J.** The returns are in. *New York Times Mag.* 26 April 1987. p. 64.
37. **Grossman H J.** *Grossman's guide to wines, beers, & spirits.* New York: Scribner's, 1983. p. 586.
38. **Garfield E.** Alcohol: are the benefits worth the risks? *Essays of an information scientist.* Philadelphia: ISI Press, 1983. Vol. 5. p. 75-83.
39. **St. Leger A S, Cochrane A L & Moore F.** Factors associated with cardiac mortality in developed countries with particular reference to the consumption of wine. *Lancet* 1:1017-20, 1979.
40. **Garfield E.** All about ulcers, antacids, and how little we know. *Op. cit.*, 1981. Vol. 4. p. 666-73.
41. ----------. All about ice cream: or, the confessions of an ice cream addict. *Ibid.*, 1983. Vol. 5. p. 20-5.