

The beginning of wine and viticulture

Invited Article

Stefan K. Estreicher*

Physics Department, Texas Tech University, Lubbock, TX 79409-1051, USA

Received 9 January 2017, accepted 13 March 2017

Published online 12 April 2017

Keywords viticulture, wine

* Corresponding author: e-mail stefan.estreicher@ttu.edu, Phone +1 806 834 3723, Fax: +1 806 742 1182

The wild ancestor of most of today's grape cultivars is the eastern *Vitis vinifera sylvestris*. Archaeological, genetic, ampelographic, and linguistic evidence point to Transcaucasia (today's Georgia, Armenia, and Azerbaijan) and Eastern Anatolia as the regions where *V.v. sylvestris* was domesticated and the first wines made. This occurred in early Neolithic times, over 8000 years ago. But the

earliest-known archeological and chemical proof of wine-making is just over 7000 years old. It was unearthed at Hajji Firuz Tepe, a Neolithic site in North-Western Iran. It took thousands of years for wine and viticulture to reach Western Europe and the rest of the world. The key points of the early history of wine and viticulture are the topic of this contribution.

© 2017 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

1 Introduction Wine pre-dates writing and the earliest civilization by more than 2000 years [1, 2]. Fermentation is a natural and unavoidable process, given a fruit with the appropriate concentrations of sugar, water, and acid. Of course, yeast must be present as well to ferment the sugars. These conditions are realized in the case of (wild) grapes. This makes it highly likely that the first fermented grape juice consumed by humans was accidental. We will never know if that wine was any good, but drinking alcohol for the first time must have felt magical. Ancient civilizations have associated over 36 gods [3] with wine, wine-making, the wine-press, and even drunkenness.

In this paper, “wine” refers to the result of the intentional fermentation of *Vitis vinifera* grapes. Proof of wine making requires dated archeological finds such as clay jars combined with the chemical analysis of the organic residue in them showing the presence of tartaric acid (the principal acid of grapes), syringic acid (from the pigmented tannin of red wine), and/or its precursor malvidin [4], remains of grapes such as twigs, pips, or even whole clusters, and/or traces of the DNA of *Saccharomyces cerevisiae*, the yeast mostly responsible for the fermentation of wine (other wild yeasts die once the ethanol concentration exceeds 5% or so). The chemical analysis involves Fourier-transform infra-red absorption spectroscopy, high-resolution liquid chromatography, mass spectrometry, or other quantitative methods.

The oldest archeological evidence of an intentionally fermented beverage does not involve *V. vinifera*, but is nevertheless worth mentioning here. It was found at Jiahu [5], an early Neolithic site near the Yellow River in China, dated over 7000 BCE (before current era). The analysis of the residue in numerous clay jars shows a blend of rice, hawthorn fruit, honey, and a native wild grape, most likely *Vitis amurensis* which grows in the region (*V. vinifera* did not exist in China at the time). This blend suggests that the drink was closer to an ancestor of rice wine than of grape wine. It is the addition of grape clusters that most likely provided the required yeast to the mix, thus allowing fermentation to take place. Even though the Neolithic people who lived at that site did not understand yeast or fermentation, they obviously figured out the necessary processes, and probably optimized them. The complex combination of ingredients also suggests that this was not their first fermented beverage.

Archeological evidence shows that *V. vinifera* wine has been made in the Near East since the Neolithic period, which lasted there from about 8500–4000 BCE. The Bronze Age began about a millennium later, as cities [6] such as Eridu or Uruk first appeared. Today's oldest proof of wine-making is dated 5400–5000 BCE. It involved the cultivated *V. vinifera* and it is clear that it was not the first wine. But the evidence of viticulture is at least 1000 years older and points to Transcaucasia and Eastern Anatolia as the locations where the

domestication of the wild *V. vinifera* most likely occurred, and the first wine produced.

2 The domestication of *V. vinifera* The wild ancestor of most modern wine cultivars is the eastern *V.v. sylvestris*. This is confirmed by extensive genetic studies of some 950 modern cultivars and 50 wild *V. vinifera* [7]. These studies also show that, after the domesticated *V.v. vinifera* arrived in the Western Mediterranean basin, it crossed with and affected the genes of the wild western *V.v. sylvestris* (the Muscat of Alexandria is one example of such a cross). Many current European cultivars show genetic contributions of western *V.v. sylvestris* [8].

V.v. sylvestris is dioecious [9, 10]: about half the plants are pollen-producing males and about half are fruit-bearing females. From an evolutionary perspective, this primitive (for plants) reproductive method indicates great antiquity. The reproduction of *V.v. sylvestris* is mediated by wind pollination, which is also a primitive form of pollination. Fossilized evidence of a related vine, *V. indovitis*, was found in late Cretaceous layers (c. 65 million years ago) [11].

The female *V.v. sylvestris* produces a small number of clusters with small, loosely-bound, watery and acidic berries, filled with pips. The female reproduces by pips. When birds eat the berries, the pips go through their digestive system and are dropped off somewhere far away, with a little fertilizer. And then, the new vine has a chance to prosper.

But a few percent of the females naturally become hermaphrodites and each flower exhibits both anthers and pistil. This involves a single genetic mutation [10]. The hermaphrodite reproduces vegetatively rather than by pips. If a branch lies on the ground for some time, a new root system develops. In the wild, the hermaphrodites never dominate because the offsprings are genetically weaker and set root too close to their parents. But the hermaphrodites produce more clusters with large berries which, at maturity, have a higher sugar content than those of females. This makes them attractive to man. They are also easy to propagate using cuttings. The wild hermaphrodites became the choice of Neolithic farmers.

Thus, the domestication of *V.v. sylvestris* occurred because man selected the best-looking wild hermaphrodites for cultivation. These evolved into *V.v. vinifera* which are almost always hermaphrodites (one of the rare exceptions is the female Almeria, also known as Ohanez). Successive selections led to plants that produce larger and sweeter berries, with a wider range of fruit colors and other desirable characteristics. Today, there are some 10,000 named *V.v. vinifera* cultivars around the world (the same cultivar sometimes has different names in different regions).

Archaeologists recognize wild from cultivated *vinifera* remains from the shape of the pips. The female pips are short and bulky while the hermaphrodite ones are thinner and more elongated [9]. When finding grape pips, archaeologists compile their width-to-length ratio. If the average W/L is greater than ~ 0.70 , then the pips most probably came from

female plants and the grapes were wild. If W/L is smaller than ~ 0.60 , the grapes were cultivated hermaphrodites [10]. The method is not fool proof, especially when only a small number of pips is found, as there are variations among subspecies and external factors (such as charring) may affect the shape of the pips.

The oldest archeological evidence of *V. vinifera* pips involves the wild *V.v. sylvestris*. It was found south of the Sea of Galilee [2] at Ohalo II, a site dated c. 18,000 BCE. This is long before any evidence of agriculture or use of clay (the earliest jars in the region are dated c. 6000 BCE). Such an accumulation of pips suggests that juice was extracted from the grapes, and then the solid leftover tossed away: leaves and skins (which rarely leave traces), and of course pips (which often survive). But the juice had to be kept in some container. Short of clay jars, this could have been the skin or stomach of a sheep for example. These rarely survive for millennia. We will never know if the juice that was likely produced at Ohalo was kept long enough for fermentation to begin. An accumulation of pips is not proof of wine.

Several converging pieces of evidence indicates that the domestication of *V.v. sylvestris* occurred some 8000 years ago either in Transcaucasia [12–14], Anatolia [15], or simultaneously in various locations because of the near-contemporary evidence of domestication. The first piece of evidence is archeological: the earliest domesticated *V. vinifera* pips were found in the oldest layers of Shulaveris–Gora [16] (south of Tbilisi in Georgia), at Shomu–Tepe (in Azerbaijan) [2], and Çayönü [17] (in Anatolia).

The second clue comes from studies of grape diversity [18, 19]. Georgia has about 500 indigenous *V. vinifera* cultivars, including some that show great antiquity such as the Rkatsileti or Mtsvane. Only a few of these 500 are cultivated today. In Anatolia, nearly 800 cultivars have been listed. Some of them are indigenous but others have been introduced. In Azerbaijan, about 250 *V. vinifera* are considered local. Such considerable diversity of indigenous wild and domesticated *V. vinifera* species is a strong indication that this entire region is where domestication occurred and the earliest wines made. Studies of the genetic relationship of 116 *V. vinifera* from the region shows that the Armenian, Georgian, and Anatolian germplasms are well separated and that domestication could have multiple origins [18].

Finally, the linguistic studies of Nikolai Vavilov [12] show that the oldest word for wine originated in Transcaucasia and Eastern Anatolia: it is the (reconstructed) Proto-Indo-European *woi-no* (or *wei-no*). As pointed out by McGovern [2] and Gorny [15], a wide range of ancient languages had words for wine that are derived from it, such as *windu* (Hattic), *īnu* (Akkadian), *yn* (Ugaritic), or *wajnu* (proto-Semitic). The Hittites had many words for specific wines: sweet wine, sour wine, new wine, honeyed wine etc., but the generic word for wine was reconstructed to be *wijana*. This shows that later civilizations borrowed an existing word for wine rather than creating a new one. Since the people who made the first wine must have created the

first word for it, this evidence supports the same Transcaucasia – Anatolia location for the origin of wine.

3 The oldest proofs of wine and wine-making Mary Voigt led excavations at the Neolithic site Hajji Firuz Tepe in North-western Iran from 1956 to 1977 [20]. Among the unearthened artefacts were six onion-shaped clay jars, each with a capacity of about 7 liters. Almost 20 years later, the organic residue in the jars was analyzed [21]. It included tartaric acid and its salt, calcium tartrate, thus proving that the jars did contain wine. Tartaric acid is the principal acid of grapes and its small shiny crystals are often left on the side of a glass, especially if it contained aged wine. Although other plants also produce tartaric acid, it is in much too low concentrations to leave the amount found in the Hajji Firuz jars.

These analyses also revealed that the inside of the jars was coated with resin from the terebinth tree. The use of this particular resin was not accidental. Neolithic people lived close to nature and knew every plant, insect, mushroom, and animal. It is very likely that they knew that the resin of the Terebinth tree had “healing” (antibacterial) properties and was somehow “magical.” Inside a jar, its presence would have inhibited the growth of the vinegar bacteria, thus preventing the wine from turning to vinegar as fast as it normally would. This allowed the wine to remain quite drinkable for a long time, maybe long enough to survive from one grape harvest to the next. Virtually all the ancient wine jars until Roman times show traces of resin from that tree (the Romans usually only resinated the neck of the jar rather than the whole interior). The resin from the Terebinth tree has nothing to do with today’s Greek “retsina” wine which contains pine resin, added for flavor (and tourists).

The use of domesticated *V. vinifera* grapes and the wine-preserving “technology” at Hajji Firuz Tepe clearly show that this was not the first wine ever made. However, that site has not revealed how this wine was made. Today’s oldest wine-making set-up was found in 2007 in a cave in Southern Armenia [4]. The site, called Areni-1, is dated 4100–4000 BCE. The finds include a shallow basin in which fresh grapes were crushed, probably stomped by foot. This basin, about 10 sq. feet in size, is made of pressed clay surrounded by a rim to contain the juice. It is positioned in such a way that the juices flow into a large buried clay jar where it could ferment and the wine stored. All sorts of remains of pressed grapes were found on site, and the analysis of the residue confirms the presence of wine in the jars. Stomping grapes by foot is a technique that has been widely used through the ages and is still occasionally used today. These buried clay jars could be the ancestor of the Anatolian *pithoi* used by the Hittites and later the Greeks, the Armenian *karas*, the Georgian *kvevris*, and the Roman *dolium*. Burying the jars not only helped control the temperature but, more importantly, prevented the jar from cracking as the CO₂ pressure built up during the fermentation.

3 The expansion of wine and viticulture Many archeological sites in modern Iran, Iraq, Syria, Lebanon,

Israel, Gaza, etc. have been found to include pips of domesticated grapes, resinated wine jars, and/or wine-making setups. Of special notice is the ancient Godin Tepe site [22, 23], a Sumerian trade center in Western Central Iran, excavated from 1965 to 1973. The site is dated 3500–3100 BCE. Numerous wine jars (c. 60 liters each) were found. Their shape was much more elongated than at Hajji Firuz Tepe. This appears to have been a storage site. Wine was clearly kept in these jars for some time, and some jars had a small hole drilled near the bottom for decanting lees. Other jars contained barley beer.

Wine and viticulture reached the Phoenicians in the 4th millennium BCE. Byblos became a center for the export of wine, and Canaan for shipping. Canaanite jars have been found along Phoenician trade routes around the Mediterranean.

The earliest evidence of wine in Ancient Egypt comes from the tomb of Scorpio I in Abydos in Southern Egypt [24]. It is dated 3150 BCE. This is very close to the time when Southern and Northern Egypt were united, marking the beginning of Dynastic Egypt. The tomb contained 700 resinated jars, 47 of which contained grape pips or even whole clusters of grapes. The total volume of buried wine was about 4500 liters.

It is not known if wine first reached the Greek islands and mainland directly from Anatolia or if it arrived with the first Phoenician traders. The oldest evidence of wine and viticulture in Greece was found at the palace of Myrtos Fournou Korifi in Crete. It is dated 2200 BCE.

The Phoenicians brought wine to North Africa (Carthage) and Southern Spain (Cádiz) around 800 BCE. The oldest wine-making setup in Western Europe is at Castillo de Doña Blanca, about half-way between Cádiz and Jerez de la Frontera. It is in the Phoenician part of the site, dated around 600 BCE.

It is likely that the Greeks from Phocaea brought viticulture with them to Marseilles around 600 BCE. There is evidence that they imported large quantities of wine from the Etruscans, but no evidence of wine-making dating back to the early days of the settlement has yet been found. The oldest wine-press on French soil was found in Lattes [25] near Montpellier. It is dated 425 BCE.

The domesticated *V. vinifera* arrived at the court of Han dynasty Emperor Wudi, in China, before 100 BCE. This occurred because Wudi sent his envoy Zhang Qian to the West. After a perilous journey that lasted from 138 to 126 BCE along what would become the Silk Road, Zhang Qian returned to Chang’an, the Chinese capital. His reports include the comment that ... *people in Daynan (Yona) and Anxi (Arshak) ... make wine from grapes*. These people could have been the descendants of soldiers of Alexander the Great’s army who settled in these areas. It is not known who brought back cuttings of these grapes to China. Maybe Zhang Qian himself? In any case, Emperor Wudi was producing some wine at his court by 100 BCE. Grape vine remained a luxury for the highest levels of Chinese nobility for almost 2000 years. Genghis Kahn had different words for “grape wine” and

“rice wine.” Marco Polo praised the *fine grape wines from Carachoco* (Turfan in North-Western China).

After Julius Cesar moved Roman legions away from the Mediterranean coast toward Central and Northern Europe around 50 BCE, the Romans established viticulture in Bordeaux, Northern France, Western Germany, and even Southern England. The Romans discovered the vines could grow in locations where the olive would not. Wine was soon found throughout Continental Europe.

Finally, *V. vinifera* reached the Americas with the Spaniard Hernán Cortés around 1500, South Africa with the Dutch Jan van Riebeeck in the 1650's, and Australia with the English Arthur Phillip in the late 1780's, nearly 8000 years after Neolithic people first tasted wine.

5 Conclusions We will never know for sure where the first wine was made. This could well have happened independently at several locations within a few centuries in Transcaucasia and Eastern Anatolia. Further, the archeological and chemical proof comes from the organic residue in jars that did contain wine. Such evidence is impossible to find before pottery itself was invented in the regions where *V.v. sylvestris* was abundant. For similar reasons, we will never know if beer, mead, or rice wine pre-date grape wine. But does this really matter? We can only hope that wine made Neolithic people happy. What is sure is that, for many millennia, alcoholic beverages were a much safer drink than water, which is easily contaminated.

Viticulture and wine spread from the Caucasus region to the entire Near East and Egypt by the 4th Millennium BCE. The Greeks made wine a very democratic drink, available to everybody. The Romans and their armies consumed considerable quantities of it and developed sophisticated screw presses for the mass-production of wine. Much of their technology was forgotten during the first half of the Middle Ages, but large-scale wine trade reappeared in the late 11th century. Viticulture arrived in Central America with the conquistadores and then made its way to South Africa, Australia, and New Zealand. Today, China is among the top five producers in the world (and growing), with a strong emphasis on red wine.

The quality of the wine produced has dramatically improved over the millennia thanks to the experience gained by generations of vine-growers and wine-makers, as well as scientific studies that led to the understanding of the importance of hygiene and of the complex bio-chemical processes involved in the alcoholic fermentation, for which Eduard Buchner received the Chemistry Nobel Prize in 1907.

Today, a large number of high-quality wines are produced by dedicated winemakers using an extraordinary array of cultivars in many countries around the world. Although the best-known wines produced in the most famous wine regions have become unaffordable to all but the wealthiest people, many quality wines with lesser-known names are very accessible. There is a universe in wine, waiting to be discovered by the thirsty and the curious.

Acknowledgements The author is thankful to S. Chatterjee for useful discussions. Many researchers have contributed to the search for the origin of wine and viticulture, but few have done as much as Patrick E. McGovern from the University of Pennsylvania Museum. Beyond archeology, the chemical analysis of organic residue in ancient jars, and genetic studies, he organized conferences and wrote popular-level books, thus reaching wider and less-educated audiences such as me.

References

- [1] *The Origins and Ancient History of Wine*, edited by P. E. McGovern, S. J. Fleming, and S. H. Katz (Gordon and Breach, Amsterdam, 2000).
- [2] P. E. McGovern, *Ancient Wine* (Princeton Univ. Press, Princeton, 2003).
- [3] P. Turner and C. R. Coulter, *Dictionary of Ancient Deities* (Oxford Univ. Press, Oxford, 2000).
- [4] H. Barnard, A. N. Dooley, G. Areshian, B. Gasparyan, and K. F. Faull, *J. Archeol. Sci.* **38**, 977 (2011).
- [5] P. E. McGovern, J. Zhang, J. Tang, Z. Zhang, G. R. Hall, R. A. Moreau, A. Nuñez, E. D. Butrym, M. P. Richards, C.-S. Wang, G. Cheng, Z. Zhao, and C. Wang, *Proc. Nat. Acad. Sci. (USA)* **101**, 17593 (2004).
- [6] The city as the origin of civilization (c. 3100 BCE) involves inhabitants who have a range of different social ranks and functions: brick makers, farmers, construction workers, soldiers, as well as wealthy merchants, land-owners, and king-priests and their immediate staff. As a consequence, the dwellings include large structures for religious or civic functions, luxurious houses or palaces for the well-off (usually at higher elevations), as well as much smaller housing units for people of lower social rank. A few very ancient ‘cities’ predate civilization, such as Çatal Höyük in Anatolia where thousands of hunter-gatherers lived. But all the dwellings were identical with no evidence of differentiation of labor, organized leadership, or social ranks.
- [7] S. Myles, A. R. Boyko, C. L. Owens, P. J. Brown, F. Grassi, M. K. Aradhya, B. Prins, A. Reynolds, J.-M. Chia, D. Ware, C. D. Bustamante, and E. S. Buckler, *Proc. Nat. Acad. Sci. (USA)* **108**, 3530 (2011).
- [8] R. Arroyo-García, L. Ruiz-García, R. Bolling, R. Ocete, M. A. López, C. Arnolds, A. Ergul, G. Söylemezoğlu, H. I. Uzun, F. Cabello, J. Ibáñez, M. K. Aradhya, A. Atanassov, I. Atanassov, S. Balint, J. L. Cenis, L. Costantini, S. Goris-Lavets, S. Grando, B. Y. Klein, P. E. McGovern, D. Merdinoglu, I. Pejic, F. Pelsy, N. Primikirios, V. Risovannaya, K. A. Roubelakis-Angelakis, H. Snoussi, P. Sotiri, S. Tamhankar, P. This, L. Troshin, J. M. Malpica, F. Lefort, and H. M. Martínez-Zapater, *Molec. Ecol.* **15**, 3707 (2006).
- [9] D. Zohary, *The domestication of the grapevine v. vinifera in the Near East*, Ref. 1, p. 23ff.
- [10] H. P. Olmo, *The origin and domestication of the vinifera grape*, Ref. 1, p. 31ff. References
- [11] The grape fossil was found in the Deccan cherts of India, together with dinosaur bones and eggs, See S. R. Manchester, D. K. Kapgate, and J. Wen, *Amer. J. Botany* **100**, 1849 (2013).
- [12] N. Vavilov, *Studies on the origin of cultivated plants* (Inst. of Applied Botanical Plant Breeding, Leningrad, 1926); *The theory of origins of cultivated plants after Darwin* (Учение о

- происхождении культурных растений после Дарвина), 1940, transl. K. Starr Chester, *The origin, variation, immunity and breeding of cultivated plants*, *Chronica Botanica* **13**, 1–366 (1951) and D. Löve, *Origin and Geography of Cultivated Plants* (Cambridge Univ. Press, Cambridge, 1992).
- [13] A. M. Negrul, Evolution of cultivated forms of grapes, *Doklady Acad. Sci. USSR* **18**, 585 (1938).
- [14] L. Levadoux, *Annales de l'Amélioration des Plantes* **1**, 59 (1956).
- [15] R. L. Gorny, *Viticulture and ancient Anatolia*, Ref. 1, p. 133ff.
- [16] R. Ramishvili, *Hist. Archeol. Ethnol. Art Hist. Ser.* **2**, 125 (1983).
- [17] R. B. Stewart, *Economic Botany* **30**, 219 (1976).
- [18] J. F. Vouillamoz, P. E. McGovern, A. Ergul, G. Söylemezoğlu, G. Tevzadze, C. P. Meredith, and M. S. Grando, *Plant Gen. Res.* **4**, 144 (2006).
- [19] G. De Lorenzis, R. Chipashvili, O. Failla, and D. Maghradze, *Plant Biol.* **15**, 154 (2015).
- [20] M. M. Voigt, Hajji Firuz Tepe, Iran—The Neolithic settlement, *Museum Monograph 50* (Univ. Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, 1983).
- [21] P. E. McGovern, D. L. Glusker, L. J. Exner, and M. M. Voigt, *Nature* **381**, 480 (1996).
- [22] V. R. Badler, *Bull. Can. Soc. Mesopotamian*, **35**, 48 (2000).
- [23] V. R. Badler, *The archeological evidence for wine-making, distribution, and consumption at proto-historic Godin Tepe*, Ref. 1, p. 45ff.
- [24] D. Cavalieri, P. E. McGovern, D. L. Hartl, R. Mortimer, and M. Polsinelli, *J. Mol. Evol.* **57**, S226 (2003).
- [25] P. E. McGovern, B. P. Luley, N. Rovira, A. Mirzoian, M. P. Callahan, K. E. Smith, G. R. Hall, T. Davidson, and J. M. Henkin, *Proc. Nat. Acad. Sci. (USA)* **110**, 10147 (2013).