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Current Opinion in Food Science

Review

Advancement and innovation in ancient wine research

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This article reviews how recent advances in archaeological and scientific methodologies have introduced a new era of research into ancient wine production and grape cultivation. Our understanding has progressed enormously since early studies in the 19th and early 20th centuries. Analytical tools can now detect and interpret the presence of wine at increasingly granular levels, while collaboration between archaeologists and scientists has explored links between ancient and modern viticulture. We discuss the development and application of ancient DNA, archaeobotany and palynology, organic residue analysis, aerial photography, and geophysical prospection in relation to the cutting-edge exploration of key debates around ancient wine: the evolution of grapevine domestication; identification of production facilities and wine drinking, storage, and transport vessels; characterization of wine properties; and the archaeology of vineyards. In doing so, we also explore future possibilities for the field, including current challenges and limitations in data and method.

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Current Opinion in Food Science 2025, **64**:101330

This review comes from a themed issue on **Innovations in Food Science**

Edited by **Heber Rodrigues**

Available online 12 July 2025

https://doi.org/10.1016/j.cofs.2025.101330

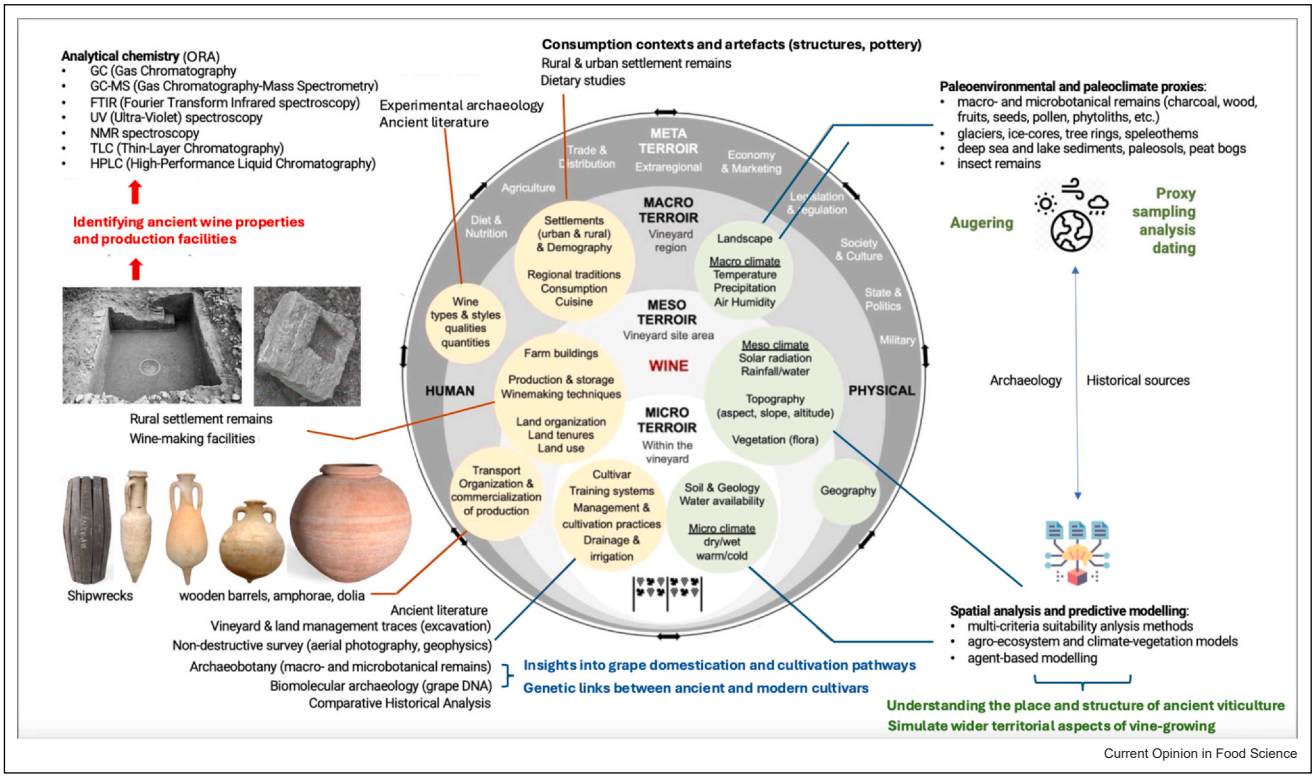
Introduction

Recent decades have witnessed a surge in research on ancient wine. Rapidly expanding archaeological data sets and the application of a range of modern scientific techniques have moved us well beyond the text-based insights of the 19th and 20th centuries (Figure 1) [1,2]. These developments extend our knowledge beyond the infamous wine cultures of Greece and Rome, reaching much earlier into prehistory and allowing us to engage with more ambitious questions and increasingly complex issues. For example, analytical tools are increasingly able to detect and interpret ephemeral material residues, illuminating the earliest events related to fermentation and grapevine domestication. Meanwhile, collaboration between scientists and archaeologists has begun to explore links between ancient and modern viticulture, including the persistence of grape varietals and impacts of past climate on cultivation and production. Research into ancient wine is now profoundly interdisciplinary, combining methods from the humanities and hard sciences to (re)investigate evidence in an increasingly holistic fashion.

Such methodological progress has led to significant intellectual advancement. More robust hypotheses have been formed around the origin(s) of wine and subsequent diffusion of knowledge, which, based on current evidence, point to the mountainous regions of Lebanon/anti-Lebanon, the Taurus, Caucasus, and Zagros during the Early Neolithic, ca. 6000 BCE [3]. Improved scientific techniques have also illustrated how Neolithic grapevine exploitation and management might have led to early wine production elsewhere (e.g. Greece and the Aegean) [4,5]. Cultures of wine consumption, and eventual production, also developed from a relatively early point in areas where the wild grapevine originally did not grow. One example comes from Old Kingdom Egypt, where vintners successfully navigated challenging arid climates and watery river delta settings as shown in royal tomb imagery, ca. 2500 BCE.

This article highlights how recent advances in methodology have ushered in a new era of ancient wine research (Figure 1). Approaches we discuss include ancient DNA (aDNA), archaeobotany (in particular seed morphology) and palynology, organic residue analysis (ORA), aerial photography, and geophysical prospection. We illustrate the development, refinement, and application of these techniques according to key themes in current debates: the evolution of grapevine domestication; identification of production facilities and wine drinking, storage, and transport vessels; characterization of wine properties; and the archaeology of vineyards. By reviewing innovative approaches as applied to these themes, we also explore future possibilities for the field, including current challenges and limitations in data and method.

Figure 1



Schematic overview of data sources and methods used to study ancient viticulture and wine production, showing where cutting-edge topics covered in the current article fit within the broader research context (diagram by D. Van Limbergen).

Ancient DNA: grapevine domestication histories and the persistence of ancient varietals

In recent years, paleogenomics (the analysis of aDNA) has developed into one of the most promising approaches to investigate the earliest histories of grapevine domestication, dissemination, and diversification. Along with other advances, next-generation sequencing technologies allow for much more rapid sequencing and enable regular, cost-effective, and reliable study of aDNA. This has been profitably applied to well-preserved archaeological remains of grape seeds, most often from waterlogged contexts.

However, while recent genetic studies incorporate vast assemblages of material, they have often led to contradictory hypotheses. Some genomic studies promote very early dual domestication events, ca. 9000 BCE in the Levant and Caucasus, based on estimated historical divergence trajectories between wild and cultivated specimens, and interconnected with societal evolution toward sedentary Neolithic agricultural settlements [6]. These chronologies are much earlier than the oldest current evidence for wine, ca. 6000 BCE (above), though depend upon a series of estimations, assumptions, and comparative calculations in their modeling and without firm archaeological evidence remain hypothetical [7]. Other research integrates genetic and archaeobotanical analyses, with results that challenge some of the domestication trends revealed by strictly genomic studies [8]. Integrative approaches using waterlogged grape pips from the Bronze Age cave site of Grotta di Pertosa (Italy) illustrate the possible transfer of domesticated grapevines from the Aegean and hybridization with local wild forms through mild selective pressure in the second millennium BCE [9]. Secondary domestication centers have also been proposed by recognizing accumulations of 'foreign' germplasm, for example, in the Albegna Valley, Italy [10].

While researchers had long assumed that grape domestication only occurred in one region and at one point in time — ca. 8000 years ago in the Caucasus — these recent genetic analyses suggest a more complex domestication pathway around the Mediterranean. Potentially independent events are now suggested for Bronze Age Sardinia and the Iberian Peninsula, with a sharp turning point toward advanced viticulture and domestication in Late Bronze Age Italy [11–13]. Some of these results remain controversial. We therefore stress the importance

of methodological rigor, including analyzing material from secure stratigraphic contexts with scientific dating conducted directly on samples rather than associated material. Methods that integrate aDNA with other evidence are likely the most reliable approach to unraveling historical grapevine and wine trajectories.

Grapevine ancestries have long been of interest to archaeologists, scientists, and modern vintners. Comparative DNA assessment and kinship analyses are uniquely placed to investigate the origins of modern cultivars, as they contribute empirical data that bridges ancient and modern viticulture. A substantial amount of this work has focused on Italy and France, regions with renowned modern viniculture and deep wine histories. Some studies reveal close genetic relationships between ancient and modern grape varietals [14], spanning even only a few generations [15]. One Medieval sample (ca. 1050–1200 CE) from an archaeological site in northern France was identified as a genetic match to modern-day Savagnin Blanc, indicating 900 years of uninterrupted vegetative propagation [14]. However, there is not yet decisive evidence for the continual growth of ancient (pre-Medieval) grape varietals today.

Despite these and other results [16], we remain unable to convincingly move beyond speculative links between modern varietals and grape descriptions in Roman texts. Ancient lineages and grape histories are powerful marketing forces in today's wine industry, but we simply do not have an evidentiary thread joining ancient literary, archaeological and modern data, and misinformation tends to dominate in promotion. Communicating paleogenetic results accurately and ethically is a prime responsibility of those undertaking research of this nature to avoid misleading the everyday consumer.

Archaeobotany: detecting the pace and place of domestication and cultivation

Developments in the scientific study of grape pips, skins, grapevine wood, and *Vitis* pollen, especially advances in computational modeling, morphometric and biometric analyses, have considerably improved our ability to distinguish between wild and domesticated samples (Figure 2) [17]. We now have a better grasp on the ways in which different taphonomic processes impact waterlogged and charred grape seeds — a crucial aspect that aids archaeological interpretation [18–20]. Analysis of uncharred, waterlogged grape pips from various archaeological contexts in France (ca. 50 BCE–500 CE) has suggested, through comparisons with modern wild grapevines and cultivars, that Roman farmers exploited a mix of morphotypes comprising wild, intermediate, and domesticated forms, while also purposefully selecting varieties with desirable qualities and undertaking hybridization [21]. Similar conclusions have recently been drawn for Roman Italy [12]. This illustrates the pace of historical domestication processes, highlighting blurred lines between exploiting wild vines and growing adapted varieties.

Similarly to genomic research, archaeobotanical studies have explored longue durée grapevine histories linked to cultural developments in wine production and grape consumption. One recent study analyzed over 19 000 grape pips covering the last 10 000 years in France to show that significant shifts toward grapevine domestication did not occur until the Iron Age on the coast (ca. 600–500 BCE) and Roman period inland [20]. These trends are almost certainly linked to an upsurge in local wine production and evolutions in wine culture within indigenous and migrant people groups. Another study evaluated several million grape pips and charcoal fragments from 330 archaeological sites to elucidate the history of grapevine cultivation in southwest Asia [22]. In tandem with data from aDNA and ORA (below), this is now painting a much more granular and diverse picture of the exploitation and dispersal of the grapevine and its interrelationship to the history of winemaking by early cultures.

Another promising line of research is palynology. While earlier efforts struggled to interpret the typically low concentrations of *Vitis* pollen — mainly because of poor insight into its dispersal patterns — more recent work has clarified its weak pollination and limited atmospheric transport. Thresholds for *Vitis* percentages in pollen spectra have since been established, and any count over ca. 0.1% of the total land pollen suggests the presence of a vineyard very close to the sampling location [23]. Notably high, outlier counts are thus extremely useful tools in demonstrating the location of past vineyards. However, good results often depend upon local environmental conditions, and some areas are not suited to this approach. The recent excavation of a vineyard near Pompeii (Italy) only delivered a single *Vitis* pollen grain from 16 samples taken within and immediately outside the trench (Figure 3) due to the poor state of pollen preservation in this area, which causes difficulties in identification [24].

Palynology can also help to ascertain the contents of ancient storage jars. A sealed *amphora* from the Albenga shipwreck (100–90 BCE) was investigated using palynological, chemical, and physical testing, which revealed that wine was its primary contents and that the high proportion of *Vitis* pollen (12.7%) might indicate that the liquid was must or wine subject to limited decantation or filtering [25]. While speculative, this highlights the potential for palynology when used on liquid samples to characterize the nature and production of an ancient wine with remarkable detail.

Figure 2

Archaeological examples of grape seeds classified as wild, *Vitis vinifera* L. spp. *Sylvestris* (1) and domesticated, *Vitis vinifera* L. spp. *Sativa* (2), recovered from Negrar, Valpolicella, Italy (photographs by D. Bellin and G. Bolognesi; courtesy P. Basso, FaW Project, University of Verona).

Organic residue analysis: identifying ancient wine properties and production facilities

Although ORA has been in use for almost half a century, only in the last few decades have more robust protocols been developed and applied to the study of ancient wine. Initially used to detect specific biomarkers or chemical signatures for wine on ceramic storage jars (e.g. *amphorae*), it is now increasingly deployed to assess production surfaces [26,27]. When used in this manner, ORA is crucial to address the persistent challenge of discerning between wine or olive oil production facilities, which in antiquity used very similar production equipment and architecture and are therefore difficult to distinguish solely through standard archaeological approaches [1,2]. ORA can also detect other chemical signatures, revealing the variety of nongrape additives that were mixed into wines in antiquity (e.g. herbs, spices, resin, seawater, honey) [28].

The scientific study of residues holds great potential to reveal information about ancient wine that was previously inaccessible or understood only through often

Figure 3

The excavated Roman vineyard and palaeosol from 79 CE at Via della Resistenza, Scafati, Italy, showing ridging, furrowing, and the location of grapevine root and stake pits (courtesy F. Seiler, SALVE project, DAI Berlin).

biased descriptions in ancient literature. Systematic applications have, for example, detected the use of various tree resins at different stages of vinification in Bronze Age Levantine cultures. At Tel Kabri, storax resin may have been used to arrest the fermentation process (perhaps added relatively quickly to must following grape treading in nearby vineyards), while *Pistacia* resin was added later to act as a preservative along with other additives during bottling and storage [29]. Sulfur has also been chemically detected in ceramic jars at several Roman sites [26], perhaps acting as a preservative in a similar manner to modern winemaking. There is, however, little supporting evidence for this practice with no mention in the otherwise detailed ancient literary descriptions of winemaking. The role of sulfur remains an important avenue of future investigation.

Comparably little research has been done on the rarely preserved liquid remains of ancient wine. One recent exception is an ash urn filled with a reddish liquid found at a Roman mausoleum in Carmona, southern Spain, whose mineral salt profile and the presence of typical polyphenols allowed for its identification as wine through inductive coupled plasma-mass spectrometry and high-performance liquid chromatography-mass spectrometry [30]. Although it will only ever be possible to assess liquid remains in exceptional circumstances, this developed procedure has the potential to significantly contribute to our knowledge on the nature of ancient wines, especially in terms of how environmental conditions, vine-growing, and winemaking procedures contributed to wine sensory profiles. Comparative modern analysis can be particularly insightful in this regard to describe how ancient wines differed from (or were similar to) wines today.

Despite the importance and frequent use of ORA in vinicultural research, methodological challenges remain (in part due to the complex nature of wine) and rarely do analyses produce indisputable results. Conclusions often require deeper and more critical reflection due to this ambiguity. For example, how many times or how often must a facility be used for sufficient residues be left for detection? Or, if wine and oil signatures are both detected, how might we interpret chronologies or phases of use (e.g. simultaneously, seasonally, or distinct and over longer time spans)? As with any archaeological science, samples should be well-provenanced, well-dated, well-preserved, and uncontaminated to produce reliable results [3]. The progressive development of ORA has also created disparate schools of work, which often disagree due to the use of different scientific approaches and theoretical underpinnings, usually in terms of chemical extraction and analysis but extending to the reliability of detecting ancient wine altogether [3,26,31–33].

Limitations also extend to revelations that describe characteristics of ancient wine as incontrovertible truths, despite requiring further experimentation and deeper critical analysis. For example, the purported detection of the color of an ancient wine based on analysis of its residues. While progress is being made regarding the

recognition of certain chemical properties that might reveal a wine or grape's color (e.g. syringic acid as a marker for red wine), in many cases, it remains inconclusive in archaeological materials [27]. This is made more problematic by tendencies to apply modern perceptions of wine color (e.g. sharp distinctions between red, white, and orange), despite arguments suggesting wines in antiquity were understood along a nuanced spectrum of shades [34]. Efforts also continue to reliably distinguish between chemical signatures for wine, vinegar, and other unfermented grape products or derivatives, all of which were produced and used in antiquity, including the suggestion of using succinic acid as a marker of fermentation [26,35].

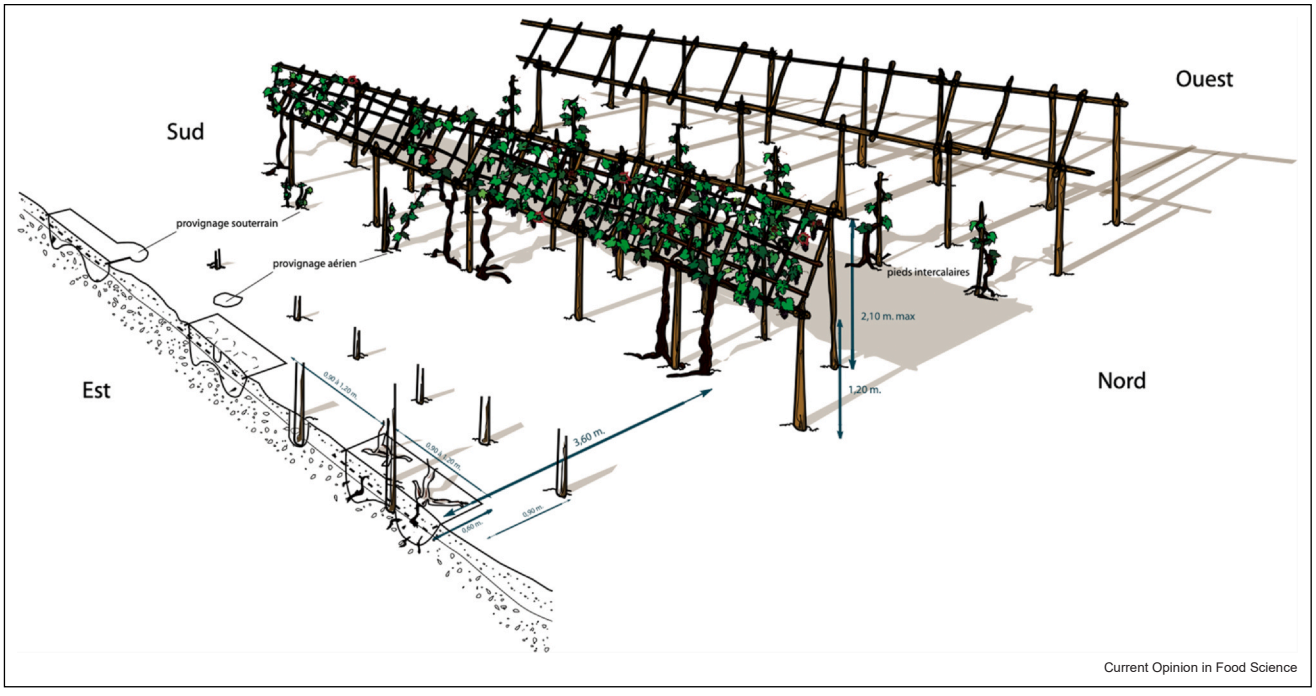
Vineyard archaeology: understanding the place and structure of ancient viticultural practice

Both excavation and noninvasive approaches, such as aerial photography and geophysical prospection, have revealed ancient vineyards in the Mediterranean and northwestern Europe, most of which date to the Greek or Roman eras (Figures 3 and 4). A particularly vast and well-studied corpus now exists for Roman Gaul, mainly generated by rescue excavations. These show examples of systematically organized trench and pit planting arrangements specifically adapted to the nature of the soil, with structural features to improve drainage and sun exposure. They also illustrate the widespread use of layering as a propagation technique aimed to quickly reproduce plants with desirable traits by partially burying their branches in the soil, establishing new roots from which a new vine is grown [36].

The oldest traces of systematic vineyards currently date from the ninth to eighth centuries BCE found in the Iberian Peninsula where they are likely associated with cultivation by Phoenician colonists [37]. Together with data from France, the Crimean Peninsula [38], Greece [39], and Italy [40], we see an expansion through Iron Age, Hellenistic, and especially Roman contexts of large, structured vineyard arrangements that testify to high levels of specialist skill, care and processes of change, and innovation and adaptation across the ancient world (Figure 4). Rigorous comparative analysis highlights the regional diversity of ancient vine-growing systems. For example, subdivided enclosures with dry-stone walls that protected vines from strong winds were used in the Hellenistic Crimea [38], and grapevines were trained as bushes or in basket shapes on Aegean islands to protect berries from harsh sun and winds [41] or along rows of host trees in the flat and humid areas of Roman Italy [42].

Geophysical prospection is increasingly used to efficiently survey landscapes that might reveal traces of ancient vineyards. Fieldwork in Italy, Spain, and the

Figure 4



Reconstruction of the Gallo-Roman vineyard at Gevrey-Chambertin, France (drawing by J.-P. Garcia; DAO: M. Foucher, after Garcia et al., 2010).

Crimea shows that this has the potential to revolutionize archaeological studies of ancient arboreal fields, in particular those dedicated to grapevines, olives, and fruit trees. In Spain, rows of cultivation pits were detected by Ground-Penetrating Radar, linked to tree- and/or vine-growing [43], while magnetometry survey at the Roman town of Lucus Feroniae in central Italy revealed parallel trenches and pits, probably representing filled cuts in the underlying bedrock from past agricultural activities [44].

These initial attempts illustrate the promise of geophysical applications in the study of ancient viticulture. Much remains to be done, however, in terms of developing and refining detection, analysis, and dating protocols to ensure that methods are rigorous and data robust. The same might be said for the use of aerial images to reconstruct ancient arboriculture. For example, linear crop marks interpreted as Roman era vineyards across the Tavoliere delle Puglie in southern Italy are visible in post-war Royal Air Force photographs and more recent aerial and satellite pictures [45], but more systematic and integrated analyses are required to reliably and effectively exploit this research method.

Spatial analysis and computational modeling: relationships with climate, topography, and society

The introduction of spatial analysis and computational modeling is a more recent evolution that aims to simulate and interrogate wider territorial aspects of vine-growing, such as land suitability, yield, and the impact of climate. For example, Agent-Based Modelling has explored the impact of climate change on vineyard profitability in southern Gaul using dynamic agro-ecosystem models based on paleoclimate data to estimate potential yields across time and space [46]. The lowest yields were found to occur in the sixth century BCE, after which they gradually increase, reaching a peak in the Roman Republican period. For each epoch, however, there was considerable spatial variation in yields, due to differences in geography and climate. Such models also suggest that in the Iron Age, the areas of highest yield potential were located on the coast, spreading further north toward the lower Rhone River basin in Roman times, probably due to a warming climate. Similar, albeit more selective work has been done on Roman Italy, in particular for Etruria and the Adriatic region [47].

Conclusion

This article outlined the enormous progress made in ancient wine research in recent decades. Alongside the range of scientific approaches described above, which are both expanding and refining our perspective across a range of aspects of viniculture, traditional methods continue to play an important role. For example, recent research into the large earthenware vessels (e.g. *pithoi* or *dolia*) that were used to ferment and store wine highlights the transfer of artisanal and technical knowledge via skilled craftspeople, from the Caucasus to the Iberian Peninsula over ca. 6500 years. This enabled the production of containers able to produce high-quality and healthy wines with the potential for taste profiles not dissimilar to some modern wines [34]. Other work illustrates the diverse range of wine production spaces and facilities in the ancient world, from rudimentary rock-cut installations in the countryside, to wineries that cluster in dense urban settings, and opulent villas that featured fountains of wine and elegant tasting spaces [48–50]. Across all these, we must navigate the challenge of modern perspectives that influence assessments of the nature and character of ancient wine. Of most importance, therefore, are multi-proxy approaches, which integrate several techniques and data sets to more reliably detect and understand the nuances of ancient viniculture.

Data Availability

No data were used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. •• Dodd E, Van Limbergen D: **Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts**. Bloomsbury; 2024.

The first volume to encapsulate the majority of modern scientific techniques and interdisciplinary approaches to investigate Roman and, more broadly, ancient wine. Approaches discussed include those within this review, along with the use of multispectral satellite data to detect vineyards, quantitative analyses of ancient yields, experimental archaeology, and GIS modeling.

2. •• Van Limbergen D, Dodd E, Busana M-S: **Vine-Growing and Winemaking in the Roman World: New Data and Original Perspectives**. Peeters; 2025.

The most up-to-date discussion of viti- and vini-culture in the Roman world, showcasing the diversity and vitality of current research, and providing a foundation for future studies. Chapters cover a vast geographical area and range of features related to Roman grapevine cultivation and wine production.

3. McGovern PE: **Ancient viniculture: a multidisciplinary holistic perspective**. In *Methods in ancient wine archaeology: scientific approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:13-32.

4. Garnier N, Valamoti SM: **Prehistoric wine making at Dikili Tash (northern Greece): integrating residue analysis and archaeobotany**. *J Archaeol Sci* 2016, **74**:195-206, https://doi.org/10.1016/j.jas.2016.03.003

5. Pagnoux CL, Bouby L, Valamoti SM, Bonhomme V, Ivorra S, Gkatzogia E, *et al*.: **Local domestication or diffusion? Insights into viticulture in Greece from Neolithic to Archaic times, using geometric morphometric analyses of archaeological grape seeds**. *J Archaeol Sci* 2021, **125**:105263, https://doi.org/10.1016/j.jas.2020.105263

6. • Dong Y, Duan S, Xia Q, Liang Z, Dong X, Margaryan K, *et al*.: **Dual domestications and origin of traits in grapevine evolution**. *Science* 2023, **379**:892-901, https://doi.org/10.1126/science.add8655.

A paleogenetic study on grapevine evolution and domestication histories using 3525 cultivated and wild accessions worldwide. The results show the impact of climate on the separation of wild grape ecotypes and conclude that two domestication events occurred ca. 11 000 years ago in western Asia and the Caucasus to create table and wine grapevines. Domesticates then dispersed with early farmers and diversified along human migration trails.

7. Zhou Y, Massonnet M, Sanjak JS, Cantu D, Gaut BS: **Evolutionary genomics of grape (*Vitis vinifera* ssp. vinifera) domestication**. *Proc Natl Acad Sci USA* 2017, **114**:11715-11720, https://doi.org/10.1073/pnas.1709257114

8. • Bouby L, Chabal L, Bonhomme V, Baly I, Battentier J, Makhad SB, *et al*.: **The Holocene history of grapevine (Vitis vinifera) and viticulture in France retraced from a large-scale archaeobotanical dataset**. *Palaeogeogr Palaeoclim Palaeoecol* 2023, **625**:111655, https://doi.org/10.1016/j.palaeo.2023.111655.

This article investigates the potential of archaeobotanical remains to trace the history of the grapevine on a large scale, across the entire Holocene period in France. A large data set of seed, fruit, and wood remains illustrate the regular presence of grapevines from the Mesolithic era to Iron Age in most regions, with sharp increases in frequency from 500 BCE. While some growth of the grapevine into central and northern France occurred during the Roman period, the main expansion occurred in the Middle Ages.

9. Breglia F, Bouby L, Wales N, Ivorra S, Fiorentino G: **Disentangling the origins of viticulture in the western Mediterranean**. *Nat Sci Rep* 2023, **13**:17284, https://doi.org/10.1038/s41598-023-44445-4

10. Firmati M, Zifferero A, Zorzi V: **Il vinum in Maremma**. *Archaeo* 2021, **37**:98-101.

11. Arroyo-García R, Ruiz-García L, Bolling L, Ocete R, López MA, Arnold C, *et al*.: **Multiple origins of cultivated grapevine (*Vitis vinifera* L. ssp. sativa) based on chloroplast DNA polymorphisms**. *Mol Ecol* 2006, **15**:3707-3714, https://doi.org/10.1111/j.1365-294x.2006.03049.x

12. Ucchesu M, Ivorra S, Bonhomme V, Pastor T, Aranguren B, Bacchetta G, *et al*.: **Tracing the emergence of domesticated grapevine in Italy**. *PLoS One* 2025, **20**:e0321653, https://doi.org/10.1371/journal.pone.0321653

13. Gismondi A, Di Marco G, Martini F, Sarti L, Crespan M, Martínez-Labarga C, *et al*.: **Grapevine carpological remains revealed the existence of a Neolithic domesticated *Vitis vinifera* L. specimen containing ancient DNA partially preserved in modern ecotypes**. *J Archaeol Sci* 2016, **69**:75-84, https://doi.org/10.1016/j.jas.2016.04.014

14. Ramos-Madrigal J, Runge AKW, Bouby L, Lacombe T, Alfredo J, Castruita S, *et al*.: **Palaeogenomic insights into the origins of French grapevine diversity**. *Nat Plants* 2019, **5**:595-603, https://doi.org/10.1038/s41477-019-0437-5

15. Raimondi S, Tumino G, Ruffa P, Boccacci P, Gambino G, Schneider A: **DNA-based genealogy reconstruction of Nebbiolo, Barbera and other ancient grapevine cultivars from northwestern Italy**. *Nat Sci Rep* 2020, **10**:15782, https://doi.org/10.1038/s41598-020-72799-6

16. Vouillamoz J, Schneider A, Grando MS: **Microsatellite analysis of alpine grape cultivars (*Vitis vinifera* L.): alleged descendants of Pliny the Elder's Raetica are genetically related**. *Genet Resour Crop Evol* 2007, **54**:1095-1104, https://doi.org/10.1007/s10722-006-9001-z

17. Carmenati R, Breglia F, Fiorentino G, Perna R: **Grapes under the lens: a methodological approach to the study of a seed assemblage from Villamagna (Urbisaglia, Italy)**. In *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:115-123.

18. Bouby L, Bonhomme V, Ivorra S, Pastor T, Rovira N, Tillier M, *et al*.: **Back from burn out: are experimentally charred grapevine pips too distorted to be characterized using morphometrics?** *Archaeol Anthr Sci* 2018, **10**:943-954, https://doi.org/10.1007/s12520-016-0425-x

19. Bouby L, Bonhomme V, Ivorra S, Pastor T: **Experimental waterlogging of grape seeds, impact on seed shape and geometrical reversing for morphometric inference**. *J Archaeol Sci Rep* 2023, **51**:104204, https://doi.org/10.1016/j.jasrep.2023.104204

20. Bouby L, Bonhomme V, Ivorra S, Bacilieri R, Makhad SB, Bonnaire E, *et al*.: **Seed morphometrics unravels the evolutionary history of grapevine in France**. *Nat Sci Rep* 2024, **14**:22207, https://doi.org/10.1038/s41598-024-72692-6

21. Bouby L, Figueiral I, Bouchette A, Rovira N, Ivorra S, *et al*.: **Bioarchaeological insights into the process of domestication of grapevine (*Vitis vinifera* L.) during Roman times in southern France**. *PLoS One* 2013, **8**:e63195, https://doi.org/10.1371/journal.pone.0063195

22. • Deckers K, Riehl S, Meadows J, Tumolo V, Hinojosa-Baliño I, Lawrence D: **A history of olive and grape cultivation in southwest Asia using charcoal and seed remains**. *PLoS One* 2024, **19**:e0303578, https://doi.org/10.1371/journal.pone.0303578.

This study evaluates over 3.9 million seeds and 124 300 charcoal fragments from sites across southwest Asia to reconstruct the history of grape and olive cultivation and consumption over 6000 years. The earliest indicators of cultivation appear in the southern Levant ca. 5000 BCE (olive) and fourth millennium BCE (grape), remaining somewhat regionally concentrated until 600 BCE. Correlations were also identified regarding climate and periods of high population density. The authors suggest that long distance trade in olives, grapes, and associated products was integral to economic, social, and demographic trajectories.

23. Brown T, Meadows I, Turner SD: **Roman viticulture from palynology: a review and new data from the British Isles**. In *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:125-144.

24. Seiler F: **New high-resolution approaches for vineyard archaeology: evidence from the region of Pompeii**. In *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:161-177.

25. Arobba D, Bulgarelli F, Camin F, Caramiello R, Larcher R, Martinelli L: **Palaeobotanical, chemical and physical investigation of the content of an ancient wine amphora from the northern Tyrrhenian sea in Italy**. *J Archaeol Sci* 2014, **45**:226-233, https://doi.org/10.1016/j.jas.2014.02.024

26. Pecci A: **Wine production, trade and consumption in the Roman world: the potential of organic residue analysis**. In *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:71-78.

27. Garnier N: **Analisi sui palmenti rupestri del Progetto Immensa Aequora**. In *A. Making Wine in Western-Mediterranean; B. Production and the Trade of Amphorae. Some New Data From Italy: Panel 3.5*. Edited by Brun J-P, Garnier N, Olcese G. Propylaeum; 2020:41-60.

28. McGovern PE, Luley BP, Rovira N, Mirzoian A, Callahan MP, Smith KE, *et al*.: **Beginning of viniculture in France**. *Proc Natl Acad Sci USA* 2013, **110**:10147-10152, https://doi.org/10.1073/pnas.1216126110

29. Yasur-Landau A, Cline EH, Koh AJ, Ratzlaff A, Goshen N, Sunsnow M, *et al*.: **The wine storage complexes at the Middle Bronze II palace of Tel Kabri: results of the 2013 and 2015 seasons**. *Am J Archaeol* 2018, **122**:309-338, https://doi.org/10.3764/aja.122.2.0309

30. Cosano D, Román JM, Esquivel D, Lafont F, Arrebola JRR: **New archaeochemical insights into Roman wine from Baetica**. *J*

Archaeol Sci Rep 2024, **57**:104636, https://doi.org/10.1016/j.jasrep.2024.104636

31. Drieu L, Rageot M, Wales N, Stern B, Lundy J, Zerrer M, *et al*.: **Is it possible to identify ancient wine production using biomolecular approaches?** *STAR* 2020, **6**:16-29, https://doi.org/10.1080/20548923.2020.1738728.
This study reviews published literature and conducts new studies to critically evaluate the range of methodological approaches used in the identification of wine using chemical analysis. It concludes that none of the currently proposed biomarkers for wine provide unequivocal evidence. Valid interpretations can only be offered using additional contextual data and through rigorous extraction and detection protocols, including the use of controls to eliminate false positives.

32. McGovern PE, Callahan MP, Hall GR, Petersen WC, Cavalieri D, Hartl DL, *et al*.: **A response to Léa Drieu et al., 2020, 'Is it possible to identify ancient wine production using biomolecular approaches?** *STAR* 2021, **7**:43-48, https://doi.org/10.1080/20548923.2021.1921934.
This article responds to Drieu et al. 2020 and argues that it is possible to identify ancient Eurasian grape wine by current biomolecular methods in conjunction with relevant archaeological, archaeobotanical, and other natural and social scientific data. It advocates for an inductive – deductive working hypothesis model.

33. Whelton HL, Hammann S, Cramp LJE, Dunne J, Roffet-Salque M, Evershed RP: **A call for caution in the analysis of lipids and other small biomolecules from archaeological contexts**. *J Archaeol Sci* 2021, **132**:105397, https://doi.org/10.1016/j.jas.2021.105397

34. Van Limbergen D, Komar P: **Making wine in earthenware vessels: a comparative approach to Roman vinification**. *Antiquity* 2024, **98**:85-101, https://doi.org/10.15184/aqy.2023.193.
This study explores Roman winemaking in dolia, challenging current ideas on ancient wine fermentation practices and sensory characteristics. It offers a novel oenological approach by comparing ancient fermentation and storage containers to modern Georgian qvevri and related techniques.

35. Amir A: **The identification of ancient wine through organic residue analysis of ceramic vessels**. *'Atiqot* 2024, **114**:179-192, https://doi.org/10.70967/2948-040X.1022

36. Boissinot P: **The archaeology of viticulture in Roman Gaul**. In *Vine-Growing and Winemaking in the Roman World: New Data and Original Perspectives*. Edited by Van Limbergen D, Dodd E, Busana MS. Peeters; 2025:123-149.

37. Gonzalez de Canales F, Montaño A, Llompart J: **The beginning of grape cultivation in the Iberian Peninsula: a reappraisal after the Huelva (southwestern Spain) archaeological finds and new radiocarbon datings. Rev**. *Onoba* 2020, **8**:35-42, https://doi.org/10.33776/onoba.v8i0.3651

38. Smekalova TN, Bevan BW, Chudin A, Garipov AS: **The discovery of an ancient Greek vineyard**. *Archaeol Prospect* 2016, **23**:15-26, https://doi.org/10.1002/arp.1517

39. Kolaiti E, Mourtzas N: **The ancient rock-cut trenches for viticulture of Paros, Antiparos, and the surrounding islets (Cyclades). In: 3rd international conference ancient Greek and Byzantine technology**. *Megaron Athens Concert Hall Athens* 2025, **19-21 ember 2024**:1-45.

40. Dodd E: **The archaeology of wine production in Roman and pre-Roman Italy**. *Am J Archaeol* 2022, **126**:443-480, https://doi.org/10.1086/719697.
This article presents a synthesis of current archaeological evidence for wine production in the Italian peninsula from the Neolithic era through to Late Antiquity. Summaries of palaeoenvironmental data are provided, highlighting new ideas regarding grapevine cultivation chronologies in Italy. Discussion traces all known archaeological evidence for different stages of the wine production process in the Roman period, including cultivation, treading, pressing, fermentation, and cellaring

41. Dodd EK: **Roman and Late Antique Wine Production in the Eastern Mediterranean: A Comparative Archaeological Study at Antiochia ad Cragum (Turkey) and Delos (Greece)**. Archaeopress; 2020.

42. Van Limbergen D: **Vine agroforestry and the rediscovery of mixed viticulture in Roman Italy**. In *Vine-growing and Winemaking in the Roman World: New Data and Original Perspectives*. Edited by Van Limbergen D, Dodd E, Busana MS. Peeters; 2025:23-44.

43. Trapero Fernandez P, Rondan Sevilla O, Lagostena Barrios L: **Studying Roman viticulture in Baetica with GIS modelling and geophysical survey**. In *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:147-160.

44. Kay S, Hay S, Smith C: **From sanctuary to settlement: mapping the development of Lucus Feroniae through geophysical prospection**. In *Roman Urbanism in Italy: Recent Discoveries and New Directions*. Edited by Launaro A. Oxbow Books; 2024:121-137.

45. Hamilton S, Whitehouse R: **Neolithic Spaces Volume 2: The Bradford Archive of Aerial Photographs**. Accordia Research Institute; 2020.

46. Bouby L, Bernigaud N, Maune S, Paradis L, Carrato C, Chabal L, *et al*.: **Viticulture in Iron Age and Roman southeastern France: a reconstruction based on charcoal and seed-fruit data compared to archaeological evidence and wine yields modelling**. *J Archaeol Sci Rep* 2025, **61**:104952, https://doi.org/10.1016/j.jasrep.2024.104952.
An updated overview of the history of viticulture in southeastern France based on multidisciplinary survey combining archaeobotanical, archaeological, and computational modeling of yields. Viticulture is detected despite the absence of wine production facilities and evidenced at the local level by the sixth to fifth centuries BCE developing in a favorable climatic context.

47. McLean A: **Modelling viticulture in the Adriatic region: a quantification of agricultural suitability**. In *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*. Edited by Dodd E, Van Limbergen D. Bloomsbury; 2024:227-244.

48. Dodd E, Van Limbergen D: **The 'place' of urban wineries and oileries in the Greek and Roman world**. *J Urban Archaeol* 2024, **9**:81-108, https://doi.org/10.1484/J.JUA.5.137202

49. Dodd E, Galli G, Frontoni R: **The spectacle of production: a Roman imperial winery at the Villa of the Quintilii, Rome**. *Antiquity* 2023, **97**:436-453, https://doi.org/10.15184/aqy.2023.18

50. Dodd E: **Visualizing the glocal through agricultural production**. In *Between Global and Local: Glocal Refractions in Roman Material Culture and Society*. Edited by Montoya González R, Dodd E. Quasar; 2025:31-46.