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Review

The Rise of Wine among Ancient Civilizations across the Mediterranean Basin

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Abstract: The purpose of this work is to present the archaeological and historical background of viticulture and winemaking from ancient times to the present day in the Mediterranean basin. According to recent archaeological, archaeochemical and archaeobotanical data, winemaking emerged during the Neolithic period (c. 7th–6th millennium BC) in the South Caucasus, situated between the basins of the Black and Caspian Seas, and subsequently reached the Iberian Peninsula and Western Europe during the local beginning of Iron Age (c. 8th century BC), following the main maritime civilizations. This review summarises the most relevant findings evidencing that the expansion of wine production, besides depending on adequate pedo-climatic conditions and wine-growing practices, also required the availability of pottery vessels to properly ferment, store and transport wine without deterioration. The domestication of wild grapevines enabled the selection of more productive varieties, further sustaining the development of wine trade. Other fermented beverages such as mead and beer gradually lost their relevance and soon wine became the most valorised. Together with grapes, it became an object and a system of value for religious rituals and social celebrations throughout successive ancient Western civilizations. Moreover, wine was used for medicinal purposes and linked to a wide variety of health benefits. In everyday life, wine was a pleasant drink consumed by the elite classes and commoner populations during jubilee years, festivals, and banquets, fulfilling the social function of easy communication. In the present work, emphasis is put on the technical interpretation of the selected archaeological and historical sources that may explain present viticultural and oenological practices. Hopefully, this review will contribute to nurturing mutual understanding between archaeologists and wine professionals.

Keywords: amphora; ancient wine; clay vessel; fermentation; *Vitis vinifera*; wild grapevine; viticultural practice



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1. Introduction

The origin of wine is intimately linked to the development of ancient civilizations and has been thoroughly described in excellent monographs edited by notable archaeologists [1–5], geographers and historians [6,7]. These works constitute the main body of knowledge further explored by marketers [8,9], physicists [10], biochemists [11] and journalists [12–15]. The authors' professional backgrounds, motivations and interests provide a wide diversity of views that assess the approach, breadth and depth of each work. Since its birth in the Middle East some 8000–9000 years ago, recent discoveries have provided new insights into the evolution of winemaking that have just been updated by Hovhannisyan et al. [16], Thurmond [17], McGovern [18], Dodd [19], Johnson [20] and Charters et al. [21]. However, the interpretation of the most recent archaeological findings by researchers with a background in wine production and practice is lacking. Therefore, the purpose of this review is to present a synopsis of the earliest historical events related to grape-growing and winemaking, from viticultural and oenological perspectives. The focus is put on

selected examples that may illustrate past techniques disseminated throughout the Black and Caspian Seas basins to the Mediterranean basin.

1.1. The Pre-Requisites for Producing Alcoholic Beverages

The production of fermented beverages and foods is contemporary with the onset and expansion of agriculture [5]. The presence of ethanol and other metabolites contributed to the preservation of dietary goods, enhancement of their palatability and digestibility, thus sustainably supporting the advancement and intensification of agriculture, horticulture and food processing techniques [11]. Cereals provided bread, olives gave oil and fruits could be consumed fresh, but the consumption of naturally fermenting juices added to the nutritional function and the role of ethanol as a psychotropic drug [22–24]. The expertise required to prevent spoilage and assure regular consumption should have been one of the main triggers of the first technological advances.

1.1.1. Fermenting Yeasts: The Agents of Ethanol Production

The basic requirements to produce fermented beverages are a sugary raw material (honey, cereals or fruits) and an appropriate vessel, so that the naturally occurring yeasts may turn sugar into ethanol [25]. Lactic acid bacteria may also originate fermented foods (e.g., cheese, choucroute) or beverages (e.g., kefir, koumiss) [26,27] and be responsible for the bioconversion of malic acid in wines (MLF: Malolactic fermentation). This fermentation usually occurs after the end of alcoholic fermentation [28]. However, they are of secondary or lesser importance concerning fruit-based fermented products.

There is a wide diversity of fermenting yeast species, but only a few can efficiently make this transformation either in yield or in quality. The predominant fermenting species is *Saccharomyces cerevisiae*, which is very rare in natural habitats. Albeit in low numbers and frequency of occurrence, its reservoirs are mainly soils under fruit trees and oaklands, thriving on sap fluxes and benefiting from decaying fruits and foliage and oak bark [29,30]. Rotten grape berries in the wild develop a succession of saprophytic aerobic microorganisms (yeasts, molds and acetic bacteria) that soon deplete carbon sources with little ethanol yield and produce objectionable metabolites such as acetic acid [31]. *S. cerevisiae* is more frequent on these decaying fruits but does not dominate the other microbiota unless the fruits are placed in a protected environment where oxygen supply is limited. Then, benefiting from its fermenting ability in a sugar-rich substrate, it produces ethanol that inhibits other microorganisms.

At the end of the 19th century, the classical Louis de Pasteur experience, where crushed grapes spontaneously fermented in laboratory flasks, if performed with sound and rot grapes, showed that *S. cerevisiae* is much more frequent in the samples with rotten grapes. It seems contradictory with its non-dominating ability in rotten berries, but the key is the closed environment in the flask. Otherwise, the microorganisms that grow faster under aerobic conditions would have dominated the process [31]. The overwhelming presence of *S. cerevisiae* in fermentation processes led Martini [32] to coin this species as the first domesticated microorganism that could have migrated to nature.

1.1.2. The Domestication of *S. cerevisiae*

The domestication process is usually associated with animals and plants, but microorganisms have also been shaped by man-made environments, as in bread baking or fermented beverages, even if our ancestors were not aware of its existence [33]. *S. cerevisiae* originated several millions of years ago from natural populations, was not associated with alcoholic beverage production, and has close relatives such as *S. bayanus* and *S. paradoxus* sharing adequate fermentative ability [34–36]. The domestication was elicited by various divergent selective pressures depending on its niche (e.g., bread, saké, beer, wine), requiring the development of customized genomes for better survival in the fermenting environments. In wine, the domestication genetic traits involve copper and sulphite resistances, fructose utilization and oligopeptide uptake [33]. Wild-type counterparts maintained genes

related to cell adherence and biofilm formation, claimed as being important to survive in nature while not necessary in liquid ferments [37]. As in other living organisms, the genetic diversity is lower in the domesticated stocks [34].

The exact origin of domestication is not yet settled and depends on increasing the number of isolates from worldwide sources. In the case of wine yeasts, 95% of strains isolated around the world belong to the same cluster [38], suggesting a unique origin of wine yeasts, followed by the expansion of populations through human activities. Fay and Benavides [34] estimated that the divergence time between the wine and saké lineages is about 11,900 years and within the vineyard group and saké group is approximately 2700 and 3800 years, respectively. Interestingly, the period is consistent with the earliest archaeological evidence for winemaking, approximately 9000 years before present times [39]. In addition, Almeida et al. [40] suggested that *S. cerevisiae* associated with Mediterranean oaks was the main progenitor of the wine yeast lineage. The discovery of highly diverged wild Chinese lineages suggests that East Asia is the center of the geographic origin of *S. cerevisiae* [37,41]. However, it is not clear if wild strains found their way to Europe and domestication was initiated independently or if domesticated ones came from Asia [33], hybridization being easy among yeast strains both in natural and domesticated environments [29].

Independently from the initial source, five distinct lineages were evidenced based on their technological and geographic origin (West African, Malaysian, North American, Saké and European/Wine), and many strains with mosaic genomes resulting from crosses between these well-defined lineages were identified [42]. A microsatellite-based study suggested that wine yeast strains (with a Lebanon cluster) could originate from Mesopotamia [38] along with the event of vine domestication that is compatible with subsequent vine dispersion [43]. Sicard and Legras [44] hypothesized that two dispersion routes could have led to domesticated fermenting yeasts into Central Europe: (i) through the Mediterranean Sea to Italy, France and Spain, and, in the case of France, from the Mediterranean coast to Burgundy through the Rhone valley and (ii) through the Danube valley. A study carried out by Capece et al. [45] showed that the flor yeasts of *Saccharomyces cerevisiae* have been frequently isolated directly from white wines, made in traditional Georgian clay vessels (*qvevri*).

Overall, the rarity of viable yeasts recovered from ancient ceramic vessels [46,47] limits the elucidation of these relationships with specimens from ancient times, but the analysis of genomic evolutionary data shows that domesticated *S. cerevisiae* strains could be traced back to sources and routes of dissemination consistent with those of grapevine and winemaking.

1.1.3. The Suitability of *S. cerevisiae* Metabolic Performance and Crop Preservation

The peculiarity of *S. cerevisiae* metabolism, where the energy-efficient respiration pathway is inhibited by high sugar concentration, makes it especially fit to produce ethanol with an average yield of 1% (*v/v*) out of 17 g/L of fermentable sugars (glucose and fructose). Indeed, sugar concentrations higher than 2 g/L inhibit respiration under a physiological mechanism known as the “Crabtree effect” [28]. However, the process is limited by yeast ethanol tolerance that rarely supersedes 16 to 17% (*v/v*), depending on the fermentation conditions. A simple calculation shows that the maximum amount of sugar to be fully fermented is less than 290 g/L. Higher sugar concentrations would lead to residual sugar in the final beverage. The process also releases carbon dioxide, resembling a boiling effect (ferment derives from the Latin *fervere*—to boil) and aromatic molecules, depending on the raw material [28]. Just imagine the attraction and surprise of the first observations where, after the “boiling”, the output was much more enjoyable and stable than the initial fruits and several degrees of pleasantness could be achieved using different substrates.

The utilisation of sugar, besides its concentration, depends on its availability by *S. cerevisiae*. High concentrations act as a preservative due to low water activity (a_w) that inhibits microbial activity. Therefore, honey may only be fermented after dilution with

water or any type of fruit juice in varying proportions, depending on the type of mead [48]. In cereals, the grains must be first soaked overnight in water to enzymatically hydrolysed starch into maltose, which is a dimer of glucose and readily fermented by *S. cerevisiae*. This saccharification process yields a relatively low amount of sugar that may be fully fermented [49,50]. Grapes and other fruits have readily fermented sugars (glucose and fructose) and so they only require some sort of juice extraction.

Another aspect of nutrient availability is the crop period and respective storage. Honey is available all year, being collected from naturally occurring beehives or from apiaries. Cereals (e.g., wheat, rice, barley, maize, etc.) are harvested at full maturity, which coincides with the spring and summer months. They may be stored and processed all year. Contrarily, fruits should be picked and fermented during a relatively short period to avoid losses. If fruits are sun-dried, the availability period may increase a little, but as a rule, the demand for a precise processing period is much stricter than for the other two sugar sources.

1.1.4. The Prevention of Spoilage

The perishability of the first fermented drinks must have been one of the main challenges tackled by our ancestors. Spoilage may be delayed with high ethanol and sugar levels (acetic acid bacteria do not proliferate over 16% ethanol, *v/v*) but, without other measures, it would be a matter of a relatively short time to occur [51,52]. Proper recipient closure to avoid air contact should have been the first recognised requirement, since evidence of clay and cork stoppers are frequent in ancient vessels [53]. Then, or simultaneously, the addition of resins to wine would have benefited preservation by microbial inhibition or by lining the entire interior of unglazed vessels [54]. The use of herbs/herbal additives (e.g., rosemary, coriander, mandrake, savory, etc.) and salt, besides flavouring, may also have some preservation effect. It seems that sulphur dioxide (SO₂), the actual most widespread preservative, was not common in ancient times [5,55].

1.2. The Role of Pictorial Art and Written Sources

The abundant pictorial depictions (e.g., frescoes-wall paintings from tombs and temples, vase paintings, sculptures, iconography, mosaics, miniatures) and the written sources (e.g., cuneiforms, epigraphs, *papyri*, *ostraca*, manuscripts) are the most relevant facts for interpreting the archaeological and winemaking evidence [1,16,56–60].

In antiquity, *papyri* and *ostraca* (fragments of pottery) have been used as common writing material in different periods of civilization. The so-called *Papyrus Ebers*, one of the oldest and best-preserved medical documents of Ancient Egypt (around 1500 BC), discovered in the Valley of the Kings, contains prescriptions for hundreds of remedies [61,62]. *Ostraca* provide detailed information about tax receipts, orders for deliveries of various goods, wine jars' tags or labels, lists, ancient scribal practices and other valuable rare records [60]. For instance, the hieratic wine jar dockets were written in black ink on one side of the vessels (sherds) and consisted of five classes of expressions (e.g., a date, the type of the wine, the delivering institution, the place of wine production and the name of the chief of the vineyard) that were found in the mortuary temple of Tuthmosis IV (the 8th pharaoh of Egypt's 18th Dynasty, c. 1400–1390 BC) in the village of Gurna, located at ancient Thebes [63]. During the 18th and 19th dynasties, the dockets were also found at Malqata, Amarna and Ramesseum, referring to wine and vineyards [64].

The inscriptions from the Israelite Samaria (the prosperous capital of the Northern Kingdom), dated to the 8th century BC, document the shipments of wine and oil from villages or royal vineyards to the capital [65,66]. Furthermore, Faigenbaum-Golovin et al. [67] discovered a 2600-year-old inscription on the back side of pottery sherd with a request for wine at the desert fortress of Arad (in modern-day Israel).

The texts with ancient technical information include those from the philosopher and naturalist Theophrastus (371–287 BC), from Lesbos and a disciple of Aristotle [68]. Several Roman agriculture manuals were credited to Cato (c. 234–149 BC), Varro (c. 116–27 BC), Columella (of Iberian origin, c. first century AD), Pliny the Elder (c. AD 23/24–79), Palla-

dius (late 4th/early 5th centuries AD) and an anonymous treatise of the tenth century AD Byzantine Greek agricultural manual *Geoponika* [19]. Interestingly, these authors depended to a great extent on translations of the agriculture book from Mago (c. 3rd–2nd centuries BC), a Carthaginian writer who is considered the “Father of Agriculture” and whose compendium was lost after the fall of Carthage (Third Punic War: 149–146 BC) (Table 1). The early treatises on medicine by physicians such as the Greek Hippocrates (c. 460–375 BC), from the island of Cos, and Galen (c. AD 129–216), from Anatolia, are relevant sources to understand wine sensory features as they were considered to be related to their medicinal properties [69].

Classical literary texts from Greek and Roman epic poets such as Homer (c. 8th century BC) (e.g., *Iliad*, *Odyssey*), Vergil (70–19 BC) (e.g., *Aeneid*, *Georgics*), Horace (65–8 BC) (e.g., *Odes*) and The Holy Books (e.g., *Bible*, *Four Gospels*, *Torah*, *Talmud*, *Islamic Quran* or *Koran*) bring additional light to the colour of the grapes, grape-growing techniques and wine styles [68]. The pictorial and written references are practically the only way to speculate on ancient techniques and wine flavours that are accurately described in many of these sources and, contrary to recent archaeological discoveries, have benefited from the continuous improvement in translation and interpretation by researchers of different epochs [70].

Table 1. Relevant ancient literary sources for understanding ancient viticulture, winemaking and wine flavours.

Title	Ancient Authors	Book Description	Modern Translation
<i>Histories</i>	Herodotus of Halicarnassus (c. 484–425 BC)	Book IX of <i>Histories</i> (I:194)-details on wine trade between Armenia and Babylon	Herodotus, <i>Hist.</i> [71]
–	Mago (a Carthaginian writer) (c. 3rd–2nd centuries BC)	‘The oldest wine author in the world’. Mago’s twenty-eight volume treatise written in the Punic language on agriculture and viticulture	The Punic text has been lost but is quoted by Roman writers
<i>De Agri Cultura</i>	Marcus Porcius Cato the Elder (c. 234–149 BC)	The earliest known and remaining complete Latin work on agriculture, about the cultivation and growth of vines, olives and fruit	Cato, <i>Agr.</i> [72]
<i>Res Rusticae</i> or <i>De Re Rustica</i>	Marcus Terentius Varro (c. 116–27 BC)	Varro’s voluminous work (a technical treatise, divided into three parts) is related to agriculture, and farm management. The first part includes viticulture and winemaking	Varro, <i>Rust.</i> [73]
<i>De Re Rustica</i>	Lucius Junius Moderatus Columella (c. 1st century AD)	Twelve-volume books of Roman agriculture. III–V and XII books describe the viticulture techniques and vinification, as well as cultivation of fruit trees and olives	Columella, <i>Rust.</i> [74–76]
<i>Opus Agriculturae</i>	Palladius Rutilius Taurus Aemilianus (late 4th/early 5th centuries AD)	The fourteen-volume books of Greco-Roman writer Palladius are an agriculture treatise	Palladius, <i>Op. Agr.</i> [77]

Table 1. Cont.

Title	Ancient Authors	Book Description	Modern Translation
<i>Historia Naturalis</i>	Gaius Plinius Secundus (Pliny the Elder) (c. AD 23/24–79)	Thirty-seven volume books. XIV, XVII and XXIII books about vine growing techniques, winemaking and cultivation of fruit trees. Also described are the healing properties and the methods of wine treatments (e.g., <i>Falernian</i> , <i>Surrentine</i> , <i>Alban</i> and <i>Pucinum</i>)	Pliny, <i>HN</i> [78–80]
<i>Geoponika</i>	Anonymous treatise: based on ancient authors' works, mostly Greeks and Romans (10th century AD)	Twenty-book collection of agricultural techniques—an edition devoted to the Byzantine Emperor Constantine VII Porphyrogenitus (AD 913–959).	Dalby [81]

2. Wine: The Permanent Trail across Western Civilizations and Religions

Our ancestors took viticulture and winemaking from the primary grape and wine-producing areas, most likely following the already existing trade of other goods [4,7,16,18,21]. In fact, maritime routes took agriculture during Neolithic times from the Levant (8500 BC) to Western Europe (5200 BC) in a journey advancing at the pace of about 1 km/year [82,83], spreading a vast array of tools and emerging technologies [84]. Table 2 shows the main archaeological milestones that illustrate the wine-growing diffusion across the Mediterranean.

Table 2. Illustrative early archaeological discoveries tracing the dissemination of viticulture and winemaking from the Near East to the Iberian Peninsula.

Periods ^a and Time Frame	Unearthed Archaeological Finds	Archaeological Key Sites ^b	Reference
NEO (7200–6500 BC)	Evidence of grape-growing (wild grape pips)	Can Hasan III, Çayönü-Anatolia, eastern Turkey ⁴	[85]
NEO (6400–5300 BC)	Remains of wild <i>sylvestris</i> forms	Argissa, Achilleion and Sesklo-Thessaly, Greece ⁹	[86]
NEO (6000 BC)	Neolithic big-sized clay jars and “possible” traces of tartaric acid	Shulaveris Gora, Marneuli district, Kvemo (Lower) Kartli province, southeastern Georgia ¹	[4]
NEO (5500–5300 BC)	Carbonized seeds of wild grapes, clay small/large storage structures	Aratashen and Aknashen villages, Armavir Province, western part of Armenia ²	[87]
NEO (5400–5000 BC)	Six jars of approximately 9 L each	Hajji Firuz Tepe, Zagros Mountains, northwestern Iran ³	[4]
LN (4460–4000 BC)	Wild charred grape seeds, pressed grape skins occasionally attached to seeds, one- and two-handled cups, red wine in a smashed, large, coarse jar and a jug	Dikili Tash site, Drama plain, Kavala district, Eastern Macedonia, northern Greece ⁸	[88,89]
LC (4300–3400 BC)	World’s earliest complete wine cellar with various wine vessels and grape remains	Areni-1 cave complex, Areni village, Vayots Dzor Province, southeastern Armenia ²	[90–92]
Chal (4000–3000 BC)	Clay jars with tartaric acid residues	Erimi village, Limassol District, Cyprus ⁵	[93]
Chal (3700–3200 BC)	Charred grape pips together with olive stones	Tell esh-Shuna (North), Jordan valley, Levant ⁶	[94]

Table 2. Cont.

Periods ^a and Time Frame	Unearthed Archaeological Finds	Archaeological Key Sites ^b	Reference
LUP (Early Period V) (3500–3100 BC)	Numerous wine jars (c. 60 L each)	Godin Tepe site, Kangavar valley, western central Iran ³	[18,95,96]
EBA (3200–1900)	Grape domestication- <i>V. vinifera</i> pips, charred berries and wood	Jericho, Israel ⁶	[94,97]
Dynasty 0 (known as Naqada IIIA2) (3150 BC)	Wine jars of 6–7 L. Intact jars with seeds, desiccated grapes/raisins with their stem, skin, seeds and dried pulp intact	Tomb U-j of King Scorpion I, Abydos, southern Egypt ⁷	[18,46]
EBA (3000 BC)	Evidence for ritual/religious consumption of wine from two zoomorphic Kura-Araxes vessels. Pollen of grapevines-as well as other non-pollen palynomorphs	Aradetis Orgora site, Kura (Mtkvari) River valley in Shida Kartli province, Georgia ¹	[98]
EBA (3rd millennium BC)	Charred finds of early grape-pressings (e.g., pips, pedicels, skin fragments)	Kurban Höyük, southeastern Anatolia, Turkey ⁴	[99]
Late EBA(2400–2100 BC)	Plastered basins for treading grapes (traces of tartaric acid) and large food storage jars; cultivation of olives	Titriş Höyük, southeastern Anatolia, Turkey ⁴	[85,100,101]
EBA (EM IIB) (2200 BC)	Evidence of wine and viticulture. Large-scale wine production is substantiated by numerous <i>pithoi</i>	Minoan Palace, Myrtos-Phournou Koryphi, Crete, Greece ¹⁰	[18]
2000 BC	Early traces of <i>Vitis</i> cultivation	Massaciuccoli Basin, Central Italy ¹²	[102]
MBA (2000–1700 BC)	Pottery production-cutaway- mouthed jugs, bowls, storage jars and large vessels	Ambelikou <i>Aletri</i> site, Cyprus ⁵	[103]
MBA (1900–1600 BC)	Wine storage cellar with jars of different capacities	Tel Kabri site, western Galilee, modern-day Israel ⁶	[104]
MBA (1650–1350 BC)	First evidence of the dimorphism of <i>Vitis</i> pollen	Terramara Santa Rosa di Poviglio site, Po Plain, Northern Italy ¹¹	[105]
BA (1500–1400 BC)	Consumption and production of wine or/and its derivatives (e.g., vinegar or must)	Two sites in northeastern Italy-Pilastrì di Bondeno (Ferrara) and Canale Anfora (Aquileia, Udine) ¹¹	[106]
MBA and LBA (1350–1150 BC)	Evidence of grapevine domestication waterlogged and uncharred pips	Nuragic culture settlement of Sa Osa, Cabras, Oristano, Sardinia, Italy ¹³	[107]
The 18th Dynasty of the New Kingdom (1332–1322 BC)	Twenty-six two-handled wine labeled amphorae with clay stopper sealings	Tutankhamun's tomb, Valley of Kings (KV 62), Western Thebes, Egypt ⁷	[108–110]
LBA (1300–1200 BC)	Full winery building within the walls of an Egyptian palace	Aphek, Central Coastal Plain, Israel ⁶	[111]
IA (1000–900 BC)	Rock-cut facility with cisterns and buried storage pits	Jezreel, Samaria, Israel ⁶	[112]
FBA (1000–900 BC)	Stone wine press in the Nuragic settlement	Nuraghe Genna Maria site, Villanovaforru, southern Sardinia, Italy ¹³	[113]
EIA (900–800 BC)	Ancient testimonies of grapevine cultivation	Sicily, southern Italy ¹⁴	[7,114]

Table 2. Cont.

Periods ^a and Time Frame	Unearthed Archaeological Finds	Archaeological Key Sites ^b	Reference
IA (900–770 BC)	Phoenician, Greek, Cypriot and Sardinian ceramics	Huelva, South-West of Spain ¹⁶	[115,116]
IA (900–600 BC)	Ancient ceramic production-red-slipped glossy pottery of the Urartian Kingdom	Bardakçı village, Van province, eastern Turkey ⁴	[117]
IA (800–700 BC)	Grape seeds and amphorae for wine transport	Eastern Iberian Peninsula ¹⁵	[118]
IA (800–600 BC)	Built-in wine press installation with plastered surfaces	Tell el-Burak, south of Sidon, modern-day Lebanon ⁶	[119]
LIA (800–400 BC)	Large numbers of Phoenician transport amphorae and <i>V. vinifera</i> seeds. Wine and olive oil production, storage and long-distance trade	Coastal site of Tell el-Burak, south of Sidon, modern-day Lebanon ⁶	[120,121]
PRIA (700–600 BC)	House winery and Phoenician amphorae	Alt de Benimaquia, Dénia, Alicante, Spain ¹⁵	[122]
PRIA (700–600 BC)	Pollen and grape seeds from domesticated vines, ceramic remains containing wine, Phoenician amphorae	Cities along the Tagus Estuary, Portugal ¹⁷	[123–126]
IA (600–500 BC)	Complex of several rock-cut presses and Phoenician amphorae	Solana de las Pillilas, Valencia, Spain ¹⁵	[127]
IA (600–100 BC)	Settlement with ceramics, rock-cut presses, vine tools	Font de la Canya, Penedès, Spain ¹⁸	[128]
PRIA (500–475 BC)	Etruscan wine amphorae, cork stoppers, grape seeds, skins and pedicels, herbal and pine-resin additives	Lattara (modern Lattes), South of Montpellier, France ¹⁹	[54]
IA (500–400 BC)	Domesticated vine charcoal identified by morphometry	Alba-la-Romaine commune, Ardèche, Rhône Valley, southern France ¹⁹	[129]
IA (500–200 BC)	Rock-cut wine presses	Rambla de la Alcantarilla, Requena, Valencia, Spain ¹⁵	[130]
PRIA (475–450 BC)	“Massaliote” wine amphorae with pine-resin	The coastal site of Lattara ¹⁹	[54]
PRIA (425–400 BC)	Limestone pressing platform (for olives or grapes)	The coastal site of Lattara ¹⁹	[54]
CP (400/300 BC–300/400 AD)	Large number of rock-cut wine presses, storage vats and clay vessels (<i>karases</i>)	Agarak village, Aragatsotn Province, Armenia ²	[131–133]
IA (357–164 BC)	Grapevine pips	Torre Montello, Magna Graecia, Taranto, Southern Italy ¹⁴	[134]
IA (300–200 BC)	Wine presses within a shrine	Sierra de San Cristóbal, Castillo de Doña Blanca, Cádiz, Spain ¹⁶	[135]
(150 BC–200 AD)	Wine production and export	Hispania Tarraconensis, Catalonia (NE Spain) ¹⁸	[136]
LH (125–100 BC)	Wine Press Complex-treading floor and a large collection tank for juice (c. 1400 L), a large buried <i>pithos</i> for fermentation	Knossos, Crete Island (Greece) ¹⁰	[137]

Table 2. Cont.

Periods ^a and Time Frame	Unearthed Archaeological Finds	Archaeological Key Sites ^b	Reference
CP (1 BC–450 AD)	Wineries in 16 Roman <i>villae</i>	Douro, Beira and Alentejo regions, Portugal ¹⁷	[138]

^a NEO = Neolithic (or New Stone Age), LN = Late Neolithic; Chal = Chalcolithic, LC = Late Chalcolithic; LUP = Late Uruk Period; BA = Bronze Age, EBA = Early Bronze Age, MBA = Middle Bronze Age, LBA = Late Bronze Age, late EBA = late Early Bronze Age, FBA = Final Bronze Age; EM IIB = Early Minoan IIB; IA = Iron Age, EIA = Early Iron Age, LIA = Late Iron Age; PRIA = Pre-Roman Iron Age; LH = Late Hellenistic; CP = Classical Period. ^b Superscript numbers correspond to the map in Figure 1.

2.1. The First Steps of Wine-Growing and Consumption

The earliest culture associated with wine, dated between 6000 and 4000 BC, emerged in the South Caucasus (also known as “Transcaucasia”), extending between the Black (west) and Caspian Seas (east) (Figure 1). Today it comprises Armenia, Georgia and Azerbaijan republics.

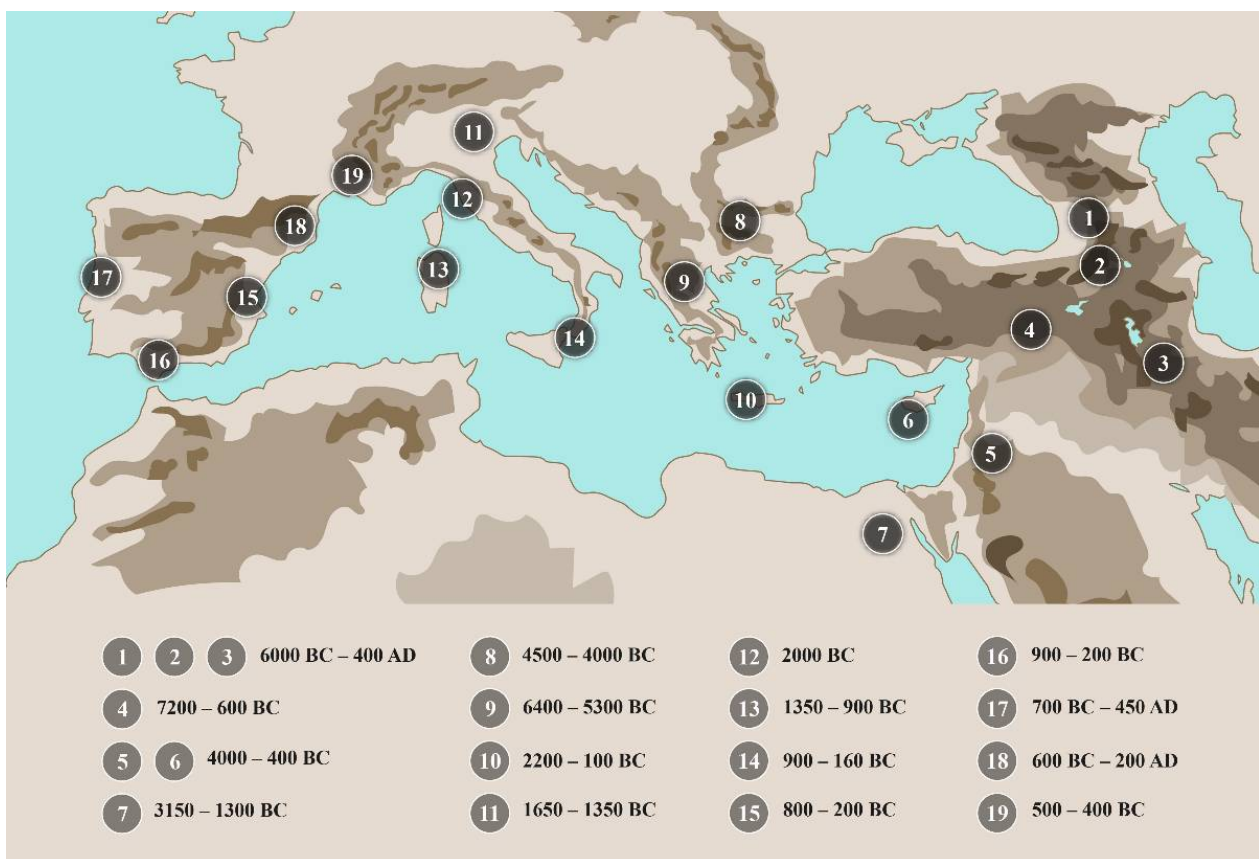


Figure 1. The distribution map of the earliest evidences of wine pottery assemblages, viticulture and winemaking. Bold numbers inside circles with the corresponding time periods indicate the locations mentioned in Table 2 (adapted by M. Harutyunyan[©], 2022).

The evidence of winemaking has been shown on sherds of pottery jars at the two Georgian Neolithic settlements of “Shulaveris Gora” and “Gadachrili Gora” (c. 6000 BC) [139] and belong to the so-called “Shulaveri-Shomu Tepe Culture” (or SSC) [140,141]. Wine remains were recovered from pottery jars found at the archaeological site of Hajji Firuz Tepe in the Zagros Mountains of north-western Iran [c. 5400–5000 BC; 18], roughly 500 km from the SSC sites. To the north of Hajji Firuz Tepe, the world’s earliest known wine-making facility was found in the cave complex of Areni-1, located near the village of Areni in the Vayots Dzor Province of south-eastern Armenia, dating back 6100 years (c. 4100 BC). The

winemaking facility was composed of a clay basin (*aragast*) for stomping grapes and a clay container (*taqar*) for collecting grape juice buried in the floor. Numerous underground vessels of varying dimensions and shapes were excavated for sediment separation, wine storage and maturation. Furthermore, the chemical analyses of organic residues extracted from the ceramic potsherds (made of fire-hardened clay) by liquid chromatography–tandem mass spectrometry (LC–MS/MS) showed the presence of tartaric acid and the red pigment anthocyanin malvidin, pointing to Late Chalcolithic red wine production and consumption on the site [90]. The winemaking facility of the Areni-1 cave complex is shown in Figure 2.

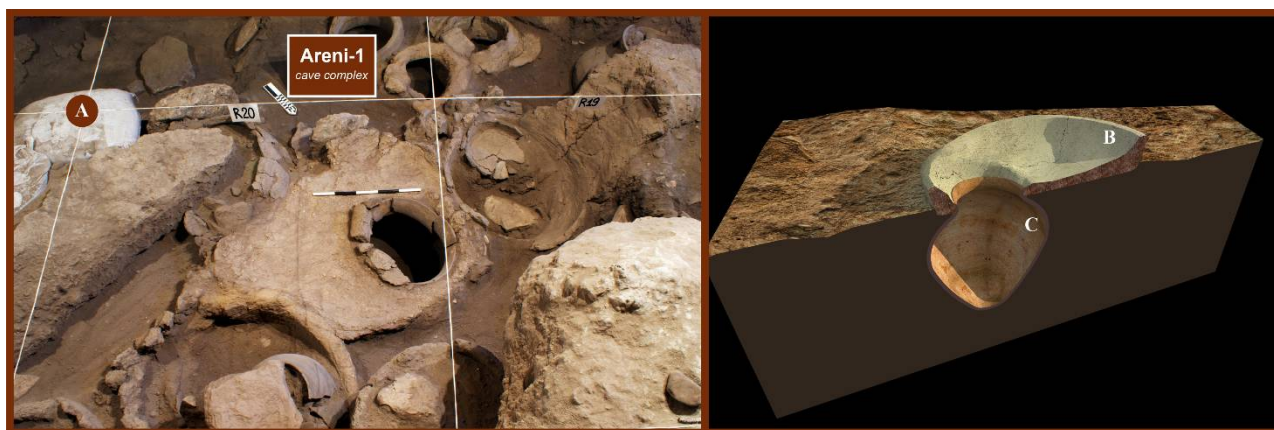


Figure 2. Wine production facility in Areni-1 site. (A) Winepress in Areni-1 cave (photo courtesy of B. Gasparyan); (B) *aragast* and (C) *taqar* of the Areni-1 cave winepress (3D profile, author A. Hakhverdyan).

The cultural chronology of the so-called Late Chalcolithic period in the Areni-1 cave complex (4300–3500 cal BC) is particularly striking. The ceramics found on site suggest that pottery vessels were hand-made with thin and thick walls made of chaff- and grit-tempered fabrics of different colours ranging from yellowish-brown to orange and grey to black and reddish yellow [92]. Ceramic vessels were decorated with intact cereal spikes, and straw was used to temper the clay to avoid both shrinkage and cracking. It is noteworthy that reed stems were used as straws for drinking wine at Areni-1 and were found in one of the earthenware *karases* near the wine pressing installation together with grape trunks [142]. From 4000 BC onwards, inhabitants of the Areni-1 cave were probably ‘pastoralists’ using the cave for different purposes. Besides winemaking, they were using the cave for habitation, animal breeding (e.g., goats, sheep and cattle) and storage of plant foods for ritual and burial purposes [92], as well as for food preparation and craft production [142], revealing clear and deep evidence for early social complexity traits [91].

Next, by 4000–2000 BC, people from the Mtkvari (Kura)-Araxes culture or Early Transcaucasian Culture (ETC) emerged in Southern Caucasus and then spread across the Near East [143]. Multiple lines of evidence (e.g., settlement patterns, ceramic analysis and textual records) were used to postulate an economic niche for the ETC in grape cultivation and wine production, resulting in the spread of wine consumption across the Near East [144].

During the Early Bronze Age (EBA: 3500–2400 BC), wine gradually spread beyond the borders of the Armenian Highlands, which lies mainly in the eastern part of Anatolia [16]. The first steps should have been taken towards Mesopotamia, East Mediterranean Basin, Northern Africa, Southern Balkans and the Levant using previous land trails [145].

During the Middle (MBA: 2400–1500 BC) and Late Bronze Ages (LBA: 1500–1200 BC), grape and wine had an important place in the Anatolian Hittite-Hurrian cultures, increasingly becoming a notable symbol of the existing developed agriculture and horticulture in the Urartian period, also known as the Kingdom of Van (Middle and Late Iron Ages: from the half of the 9th century to the end of the 7th century BC) [16,146].

During the Late Bronze Age (LBA) of the Hittites, the logograms *wiyana-* and *e/ippiya-* corresponding to “wine” and “vine” were presented [147]. The Hittite cuneiform texts indicate that wine as a beverage was an important product and served a multitude of needs within the circles of the Hittite elite. Wine apparently was reserved for royal consumption, while beer was the preferred beverage of the lower classes. In the religious sphere, wine was used primarily for libations and supplications, propitiating the diverse divinities of the Hittite pantheon. Moreover, wine was offered as a tribute during various occasions [85]. Hittite ritual texts contain data on a beverage called “*marnuva*”, used during the ritual ceremonies of the royal family, including the rite dedicated to the weather god. It is remarkable that in the Christian world-outlook, and, thus, in the Hittite rituals, there were references to the interrelation of bread and wine [148]. Zoomorphic (animal-shaped vessels) and anthropomorphic (decorated with a human face in relief) ritual vessels were common throughout the 2nd millennium BC and were used in the Hittite cult in relation to a god serving and/or drinking [149]. In the Urartian period, *Haldi* was the deity of grapes and wine [16].

At least since the 3rd millennium BC Armenian wine was traded in the markets of the Near East and exported to Babylon and Mesopotamia, mainly by waterways through the Euphrates and Tigris rivers or through the Zagros Mountains overland from the Caspian Sea [150]. At the beginning of the 2nd millennium BC, the wine trade of the Near East was controlled by the Mesopotamian city-state of Mari, located in the middle reaches of the Euphrates River. Wine from the production regions was brought to Mari through the river, stored and then transported by river to the cities of southern Mesopotamia [151]. The markets of southern Mesopotamia were especially profitable for Armenian wines [152]. Wine was transported in storage vessels (called *našpakum*, roughly 3000 L) and stored in the palace buildings or in storerooms. From the archives of the Babylonian city of Mari it can be concluded that mainly red wines were consumed, but white wines were also brought to Mari [153].

Neolithic–Predynastic Egypt, spanning the interval from 5000 to 3100 BC, was inhabited by early refugees from the Fertile Crescent (i.e., situated between the Tigris, Euphrates and Nile rivers) who established numerous settlements in permanent villages, contributing to population growth. The Canaanites from the Levantine region were the first to trade with Egyptians during the Archaic or Early Dynastic Period (EDP: c. 3000 BC) [154]. These early winemakers arrived in Egypt, where there were no vines, and rapidly established themselves as suppliers of the Pharaohs, initiating the grounds for a strong, productive and commercial activity [18]. In Egyptian mythology, the god Osiris was called “The Lord of the wine” in the Old Kingdom (2575–2150 BC) Pyramid Texts. Osiris’ resurrection was symbolized by the grapevine, which adorned the Theban tombs [18]. In ancient Egypt, wine was mainly consumed by the royal family and higher ranks of society, being offered to the gods by pharaohs and priests in daily temple rituals dating from the New Kingdom (1539–1075 BC) to the Graeco-Roman period (332 BC–395 AD) [110]. Egyptians knew drunkenness and represented obvious cases in drawings on *papyri* and in tomb paintings. Viticulture and wine-making scenes include vineyard and grape treading, straining and pressing grape juice, picking, crushing, vintage and fowling, with pressing scenes showing stoppered and unstoppered wine jars. Larger quantities of wine were consumed during jubilee years, festivals and banquets, more than during ordinary events and circumstances. It also accompanied the dead as a symbol of a good afterlife [61,155]. In Egyptian banquet scenes, seating was hierarchical, the higher-status individuals seated near the tomb owner on high-backed chairs, the lowest status at a distance kneeling on reed mats [156]. The Near Eastern feasting and drinking ceremonies during the subsequent Iron Age should have also strongly influenced the shaping of the Archaic Greek *symposium* drinking party [157].

2.2. From the Levant to the Italian Peninsula

Besides Egypt, wine held a key role in the emergence of the Bronze Age civilizations of the Fertile Crescent (Sumerians, Akkadians, Assyrians and Babylonians). The short sea

trips would have made Cyprus, Crete (Knossos) and other Greek islands easily reachable and home of the Minoans and Mycenaeans. The textual evidence underlines the luxury nature of wine, its ritualistic relation, funerary customs and feasting [58,153,158].

The Levant was inhabited by a succession of peoples (e.g., Canaanites, Philistines and Israelites) where the Phoenicians played the most important role in spreading wine drinking culture throughout the ancient Mediterranean world [159]. After the close of the Late Bronze Age, wine played an important role in many regions of the Iron Age Mediterranean (c. 1st millennium BC). The Iron Age wine production, storage and consumption are evidenced by the variety of transport containers (*amphorae*) in large quantities and well-known structures (e.g., presses, masonry vats, storage facilities and equipment) associated with wine or olive oil production [70,160]. In particular, excavations at the coastal site of Tell el-Burak have revealed a well-preserved 2600-year-old Phoenician wine press, considered as the first Iron Age wine press in modern-day Lebanon [119]. The Phoenician civilization was founded on the trade of valuable goods and merchant activities from the cities located in contemporary Lebanon and flourished between 1500 and 300 BC.

The earliest evidence (2nd millennium BC) of viticulture and wine production in present-day Italy comes from northern [105] and northeastern areas [106] and the Sardinian region [107]. In Tuscany (central Italy), there are also early traces of *Vitis* cultivation around 2000 BC in the Massaciuccoli Basin [102]. The early consumption of wine and/or grape-derived liquids is attested at the two archaeological sites in northeastern Italy. At both sites, tartaric acid on pottery vessels of the Bronze Age, *Vitis vinifera* macro-remains, traces of sulphur dioxide and *Pinaceae* products were unearthed and dated to 1500–1400 BC [106]. The evidence of winemaking from the latest phase of the Late Bronze Age is also confirmed by the presence of tartaric acid residues from a stone wine press found at the Nuraghe Genna Maria site of southern Sardinia, dating back to the 10th and 9th centuries BC [113].

Wine has become an integral part of the religious symbols of civilizations. In ancient Greece, it was linked to Zeus and Dionysus followed by the Roman Jupiter and Bacchus. Among the Babylonians of Mesopotamia (c. 2000–539 BC), Siduri was a goddess of wine [4]. Dionysus and Bacchus were significant members of the pantheon of the gods, with a substantial mythology that fixed the importance of wine [8]. Besides being the god of the grapevine and wine, Dionysus became a metaphor for birth, fertility and resurrection in nature [161,162]. The legend of Dionysus assumes that he was born in the east, from Anatolia to Iran and Iraq [163], where wine was supposedly first produced.

2.3. Carthaginian and Greek Trade Closing the Mediterranean Arch

Carthage, a Phoenician colony in present Tunisia, was the main centre of dissemination to Sicily, Sardinia, Corsica and Iberian western shores since at least 800 BC. Passing the Gibraltar strait, the Phoenicians left their mark on the Cadiz region of southern Spain. The nearby archaeological site of Castillo de Doña Blanca has remains from the Bronze Age and shows continuous occupation from the eighth century BC until the end of third century BC [164]. At that time, the local people were in the final Bronze period (13th–9th centuries BC), populating mainly the inland [122,165]. Viticulture appears to have spread rapidly to the interior of the peninsula, where there is evidence of viticulture in the Ebro valley from at least the end of the seventh century BC [118].

The first stage of the Iron Age on southern Portuguese shores (800–600 BC) was developed by eastern Mediterranean peoples of Phoenician origin [166]. There are few known archaeological remains, which do not give an accurate idea of the true dimension of Phoenician wine in the current Portuguese territory. The most important remains were discovered along the navigable waterways, such as the southern estuaries of Sado, Tagus, Guadiana and Arade rivers, and in inland regions such as Azougada (Beja district). However, references are only made to fish preserves and olive oil [167]. These new settlers mixed with locals and were dedicated to farming, fish transformation and trade until the arrival of Roman colonization. Interestingly, in Lisbon, a *karstic* cave was discovered with religious remains from the 8th century BC, typical of the Phoenician occupation [166].

On the northern Mediterranean shore, the Greeks dominated the sea trade, and wine reached Magna Graecia (Southern Italy), Etruria and Lazio [17,168]. Eventually, the Mediterranean arch was closed when the Punic merchants traded wine with the Gauls by the 8th century BC in the Languedoc [169]. After, Etruscan, and mainly Greek colonisers, settled since the sixth century in Catalonian and Valencian shores, were receiving wines from Massalia (Marseille, Southern France) and Etruria (Tuscany, Central Italy) [118]. In Mallorca (Balearic Islands, Spain), vine stocks and wine amphorae from the eastern Mediterranean were recovered from a shipwreck dated to around 375 BC, showing the interactions between both shores of the sea, that may explain the dispersion of grape varieties [118].

During the 3rd century BC there seems to have been a decline in Iberian wine production and trade [170], probably reflecting the three Punic Wars (264–146 BC) that put an end to the Carthaginian domination. Afterwards, the Romanization period covered the entire Iberian Peninsula and established a strong and durable grape and wine production, as illustrated by numerous wineries within Roman *villae* [138,171].

In parallel, wine was taken to Central Europe, mainly through the main trade routes of the Rhine, Rhone and Danube rivers. Meanwhile, during the 4th century BC grapevine cultivation reached Central Asia, and approximately the 2nd century BC domesticated grapes were introduced into China and Japan [4,172].

3. The Origin and Dissemination of Grape-Growing

The origin of viticulture and winemaking is closely intertwined. From a modern perspective, it would appear that grapevine cultivation/viticulture should have preceded winemaking, but wine may have begun simply with the handpicking of the wild grape berries and putting them to ferment in vessels/jars. However, the discovery of grape seeds does not by itself demonstrate the production of wine, because berries could be consumed fresh or dried.

3.1. Grapevine Primary Domestication Centres

The primitive *Vitis* genus was a hermaphrodite plant at the end of the Cenozoic period that became a dioecious plant during the Quaternary glaciations, being distributed all over Europe and the Near East [173]. Present Iberian populations were separated from the Eastern ones during the last Glacial period [174]. Grapes were already found during the Palaeolithic and Mesolithic times by hunter-gatherers in many areas of the Near East and in the Mediterranean region [86,97,175]. The existence of grapevines in the Armenian Highlands, Anatolian Plateau and the South Caucasus has been attested since the first agricultural communities, dating back to the 7th and 6th millennium BC [85,87,143].

Wild grapevine is a riparian climbing plant suffering from habitat fragmentation [176] and the arrival of North American pests (*Phylloxera*) and pathogens (Downy and Powdery Mildews) over the last 150 years [177] that played a significant role in the reduction in their populations. However, they still occur in northern Africa, Middle East and in the Mediterranean, Black and Caspian Seas Basins from the Iberian Peninsula to Turkmenistan [43]. In particular, wild grapes were found in the mountainous areas and riverbank forests in the Syunik region, the southernmost province of Armenia [178]. In Alentejo province, large populations were first reported by Ocete et al. [179] along the Guadiana River, presently under the waters of the Alqueva dam. Later observations showed that *V. sylvestris* populations are still frequent in the southern part of Portugal, along other river basins [180–182] (Table 3). These natural populations are mainly composed by male plants, producing large amounts of pollen, by female plants in lesser proportion and by rare hermaphrodite individuals [183]. In evolutionary terms, hermaphrodites are less advanced than dioecious but, in nature, the process may be reversed [184] and hermaphroditism in *V. vinifera* results from a mutation in wild male plants [185–187].

Table 3. Localization of the wild grapevine populations (*Vitis vinifera* L. subsp. *sylvestris*) (all red grapes) in Portugal (Personal communication, Antero Martins 2020).

River Basins	Number of Sites	Wine Denomination (Municipalities)
Tagus River (right bank)	1	Beira Interior (Castelo Branco)
Tagus River (left bank)	4	Alentejo (Montemor)
Sado River	3	Alentejo (Vendas Novas, Évora)
Guadiana River	2	Alentejo (Évora, Redondo, Portel)
Guadiana River	5	Alentejo (Serpa, Barrancos)
Sado River	10	Península de Setúbal (Vendas Novas, Alcácer do Sal)
Arade River	2	Algarve (Monchique)

Grape domestication comprised the selection of lesser evolved hermaphrodite plants that had larger and sweeter berries together with pruning to increase the yield [99], but female plants could also have been selected [183]. Present hypotheses place domestication about 8000–9000 years ago, during the Neolithic Age, through a long and gradual process closely linked to winemaking [18,145,172]. Archaeological remains, proto-historical sources and genomic analysis suggest the “SSC” area as the first centre of domestication [4,90,172,188]. Interestingly, the biblical tradition says that “Patriarch Noah, a man of the soil, after the Great Flood, descended from ark sheltered on the Mount Ararat, planted the first grapevine, and made wine” (Genesis 9:20–21). Other flood myths are also placed in the same broad area. These myths and biblical stories were confirmed through archaeological and archaeobotanical research, which eventually came to be known as the “Noah Hypothesis” of the origin of winemaking [18]. McGovern [18] reported the recent observation of hermaphrodite plants among the dioecious counterparts in this region, which could be the object of selection due to higher fruit production. In the cave complex of Areni-1, the remains of grape seeds found in the jars attributed to the domesticated grapevines, providing evidence of vine cultivation [91]. However, the dating of domestication is subject to discussion once Zohary et al. [97] considered the Levant region (Jordan and Israel), during the Early Bronze Age (3500–3300 cal BP), to be the first place where domesticated varieties were surely used. Notably, these authors admit to earlier dates in the region if further studies are carried out. Apparently, the incorrect supposition that winemaking relics are definite indicators of the existence of domesticated plants and the variability in seed sizes contributed to the discussion [189].

Chemical Analysis of *V. sylvestris* Wines

Table 4 shows a comparison between chemical analysis of wines obtained from wild, mostly red and domesticated grapes. Ocete et al. [190] highlight the high colour intensity, which attributed the low yield of juice (16% instead of the usual 80%), low ethanol and the high total acidity characteristic of wild varieties. Cantos et al. [191] and Drori et al. [192] also found high colour intensity and acidity while a higher ethanol concentration was obtained, reflecting higher sugar at maturation. Bornice [193] reported equivalent data within a cultivated collection of wild grapevines where the anthocyanin content, responsible for the red colour, was higher than that of the *Sangiovese* variety. Interestingly, Drori et al. [192] showed less ethanol for domesticated varieties grown in the wild that could be attributed to the climbing mode of growth. According to these data, *V. sylvestris* could well give acceptable wines, somewhat bitter and acidic, even without being pruned and trained like the domesticated vines. In fact, Valamoti et al. [189] posited that the amount of wine drunk in the prehistoric Peloponnese (c. 2500 BC) of southern Greece could only be achieved with wild grapes intensively managed or grown in vineyards, anticipating the cultivation of primitive varietals. In the Peloponnese region, the wine drinking culture flourished during the 2nd millennium BC with the advent of the Mycenaean palatial societies [189].

Table 4. Wine composition of wild and domesticated red grapevines.

Sub-Species	Ethanol (% <i>v/v</i>)	Total Acidity (g/L)	pH	Colour Intensity	Region	Reference
<i>V. sylvestris</i>	8.5–10.8	8.2–9.5	3.40–3.53	10.2–11.5	Northeastern Spain	[190]
<i>V. sylvestris</i>	10.8–13.4	8.6–9.4	3.25–3.61	10.6–12.4	Andalusia, Southern Spain	[191]
<i>V. sativa</i>	11.0–11.9	2.6–6.0	3.52–3.88	2.5–8.6	Israel	[192]
<i>V. sylvestris</i>	11.2–14.4	5.6–7.3	3.14–3.72	10.8–21.7	Israel	[192]
<i>V. sylvestris</i>	8.2–13.0	4.1–7.5	3.21–4.22	—	Tuscany, Italy	[193]

3.2. Secondary Sites of Domestication

The existence of wild grapevines in other places contemporary to the Eastern *V. sylvestris* populations supported the hypotheses of other domestication events along the Mediterranean basin, including the Iberian Peninsula [43,181,194–197]. The process of secondary domestication is subject to discussion because of hybridization between both subspecies and the existence of feral populations (*V. sativa* that grow in the wild). The genetic process is called introgression, where a gene from one species is introduced into another one by an initial cross between the donor and the receiver species, followed by repeated crosses with the receiver [196]. Thus, the present difficulty in identifying true *V. sylvestris* is not surprising [198]. This author concluded that the evidence of introgression of *V. sylvestris* genes into cultivated varieties, although at a much lower rate than in the opposite direction, supports separate but secondary domestication events along several dispersion routes from the origin in the Near East. To support the Iberian Peninsula as a secondary domestication site, the local varieties share the chlorotype “A”, different from the “B” and “C” characteristic of Transcaucasian wild and domesticated vines [187].

In Italy, grapevine remains were rare in the Mesolithic sites, but increased during the Neolithic period and became frequent in the Bronze Age, suggesting that the critical period of grapevine domestication could be placed between the Bronze Age and Early Iron Age. This domestication did not originate from the local wild indigenous plants but from their hybrids, with domesticated vines of Mycenaean and Hellenic origin [199], which in their turn might have come from the Black Sea area [189]. In Portugal, grapevine seeds have been found in the northeast region, close to Spain, from the Neolithic and Bronze Ages [173,200], while the oldest domesticated ones only appeared in the seventh century BC in the area of the Iberian Phoenician colonies along the Tagus River [123,186].

The existence of unique domestication centres in each wine producing region would be extremely attractive to support the national origin of varieties. However, the dating of domesticated grape remains has been consistent with the likely arrival of domesticated plants brought by Greek or Phoenician settlers [145]. The possibility of any direct domestication in those sites and development of original viticulture by indigenous peoples would have been hampered by the arrival of eastern *V. sativa* cultivars that crossed with the local *V. sylvestris* ones and prompted viticulture evolution. Even in Greece, where wild grape cultivation can be traced to the Chalcolithic Age, the *V. sativa* varieties might have been introduced through the contact networks established through Bronze Age trade routes, which connected mainland Greece with the Mediterranean and Black Seas areas [189].

3.3. The Ancestry of Grape Varieties and Viticultural Practices

The favourable climatic and growing conditions and the natural hybridization between wild and domesticated plants contribute to the high diversity of varieties in Armenia [201], Georgia [202], Portugal and Spain [203]. Cultivated varieties have a genetic variation in quantitative traits (e.g., productivity, sugar and anthocyanin contents), but since they are propagated by vegetative (asexual) techniques, the main genetic information determining ampelographic characteristics (e.g., leaf shape, flower sex) remains stable for centuries while new *V. sylvestris* populations are spontaneously and continuously appearing in their natural habitats [183]. Roman agriculture texts include descriptions of a wide variety of

domesticated varieties according to their quality (first, second and third categories) and purposes (table or wine) [204] that could be the domesticated ancestors of the present ones.

Recent genomic-based research evidences the ancient dissemination of domesticated varieties across the Mediterranean basin. Vouillamoz et al. [205] showed that four varieties from Western Europe ('Chasselas', 'Nebbiolo', 'Pinot Noir' and 'Syrah') have a close relationship to a group of Georgian cultivars, closer than to Armenian and Turkish traditional grape cultivars, suggesting a possible ancient origin in Georgia. A recent exhaustive study of microsatellite (SSR) diversity also strongly implicates samples of *V. sylvestris* from Georgia in the major cultivation event [188]. A genetic study of the medieval (780–1000 cal AD) grape stems, discovered in the Areni-1 cave, showed very close genetic relationships between the medieval remains and the 'Sev Areni' ('Black Areni') variety growing in the same area (Noravank Monastery, Gnishikadzor canyon, Vayots Dzor Province) [206]. Recently, the genetic analysis of numerous Armenian cultivars by combining SNP and SSR profiling identifies multiple cases of synonyms, homonyms, and misnames and the first pedigrees for some of the cultivars by the determination of a series of new trios and duos [207]. In France, Ramos-Madrigal et al. [208] compared Iron Age, Roman era and medieval period grape seeds with present domesticated and wild ones and reported that the archaeological samples were closely related to western European cultivars used for winemaking today. In particular, one seed dated to c. 1100 AD was a genetic match to *Savagnin Blanc*, providing evidence for 900 years of uninterrupted vegetative propagation [208]. Especially in the context of hybridization in northwestern Iberia, the study of morphometric analyses carried out by Boso et al. [209] showed that the waterlogged grape seeds from several Galician archaeological sites are grouped with medieval and Roman seeds close to the modern Portuguese white 'Alvarinho' or Spanish 'Albariño' variety.

Cunha et al. [203] demonstrated that some Portuguese varieties are derived from local wild populations. Interestingly, these authors found at the core of the genetic network the variety 'Marufo', which is a female non-self-pollinating fertile variety because the stamens are retroflexed and the pollen is sterile, as in the *V. sylvestris* flowers [210]. Another grape variety, 'Vinhão' (meaning 'big red'), was also closely related to *V. sylvestris*, and it is characterised by high colour intensity, such as its wild counterparts. Probably, these varieties could be included in the so-called group of para-domesticated ones [145]. Furthermore, Cunha et al. [203] showed that other Portuguese varieties were descendants of the *Savagnin Blanc*, which is not unexpected since viticulture was developed by Cistercian monks.

3.4. Vine Training

The ancient viticulture techniques were thoroughly described in classical texts and rigorously analysed by Billiard [204] and, more recently, by Vandermercsh [211] and Thurmond [17]. These texts demonstrate the high skills and the depth of knowledge based on empirical observation of the first *vignerons*.

Under the scope of this review, the single question to focus on is related to the training system, because it illustrates the transition between a system similar to the first wild vines (growing as lianas) and the present low growing training dependent on severe pruning. The first viticulture practices should have profited from the climbing nature of the wild plant, charcoal remains of willow trees being observed that were often used as supporters for grapevines with high trunks to protect from wind, along with *V. sylvestris* in Greece during the Early Bronze Age [189]. Similarly, grapevine, along with Salicaceae family (willow or poplar) charcoal, has been found in southern France during the Iron Age [129]. It is likely that the first domesticated vines were also grown to height using poles (*pergola*), as depicted in Egyptian tombs, where the natural *V. sylvestris* did not exist. Tree climbing vines together with pruned low vines were common in Magna Graecia (Southern Italy) and Sicily under Greek influence during the fourth and third centuries BC [17]. Since the time of the Urartian Kingdom (Middle and Late Iron Ages), vine cultivation was practiced not only in the plains and the foothills, but also in the highlands. The remnants of these vineyards were preserved in the Vayots Dzor Region, not far from the Gndevank

Monastery [16]. The archaeological findings in the northeastern Anatolian province of Erzurum revealed that the ‘Karaerik’ cultivar, which is a red grape variety indigenous to Turkey, is trained in an old traditional *Baran* training system to avoid cold winter damage (i.e., to cover the grapevine with soil). This viticultural management practice has remained essentially unchanged since 800 BC [212]. In Cherchell (Algeria), Roman mosaics dating to the 3rd century AD show pictures of low and high vines being pruned, revealing the coexistence of both training options [171]. This vine-growing practice was known as *anadendras* in Greek [189] or *arbustum* in Latin and may be defined as a plantation with vines trained on rows of host trees placed within crop fields [213]. This author highlighted its importance beyond subsistence agriculture in commercial farming by reviewing the textual sources of Cato (2nd century BC) and, two centuries later, of Pliny the Elder and of Columella. These ancient authors noted the good quality of wines from *arbustum*-grown grapes [211]. In Tuscany, the decline in the *arbustum* may have been situated around 200 BC, as evidenced by a sudden increase in the size of recovered grape seeds [214].

Interestingly, domesticated vines climbing the trees are still observed in northwestern Portugal, known as “vinha de enforcado”, meaning “hanged man vines”, while in Tuscany they are known as “vite maritate” (married vine) [215].

4. Conclusions

In conclusion, the Mediterranean region witnessed the succession of different civilizations and peoples, but wine was a permanent commodity among the most prized goods. The wine trade was one of the main incentives for the Canaanites, followed by the Phoenicians, Greeks, Etruscans and Romans, to expand their influence in the Mediterranean Sea. The following wine expansion into the New World engaged by Portuguese and Spanish seafarers can be interpreted as the succession of their Mediterranean ancestors.

However, the question of why this process did not occur elsewhere in the world remains. Wild grapes are also native in Northern America, but there is little evidence of early wine production before European colonization [186]. Even in China, where wine appeared to have had similar chances to flourish (e.g., grapes, vessels, medicinal use, ruling elite preference) [62], it failed to achieve similar social importance as in the West. For a contemporary wine enthusiast, it would be tempting to explain this success of wine based solely on the greater appreciation of its flavour properties compared to other drinks, but in antiquity, wine recognition could not be dissociated from its nutritional, social, spiritual and medicinal associations. In particular, the symbolic associations with religious belief, fertility and health are the most pervasive [8]. Then, the reasons underlying its success should not be only related to the expertise to obtain a drink preferred over others, but also with the way Mediterranean peoples incorporated wine in all aspects of their lives.

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