

Evolution Of Greek Wine Industry And Its Ecological Footprint

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Abstract— Wine is one of the most popular alcoholic beverages globally and demand for it is only rising. Making wine is a multi-step, intricate process that yields a significant number of inorganic and organic waste. It is impossible to manage these wastes if we rely only on their release into the environment. In recent years, new and successful ways of utilizing waste in various environments have emerged.

Keywords—winemaking; wine by products; circular economy; history of wine; ecological footprint

INTRODUCTION

Since ancient times, people have enjoyed drinking wine. Our natural preference for this beverage results from its fantastic flavor, nutritional value, and last but not least, psychoactive (intoxicating) effects. None of the alcoholic beverages have had such an effect on society. Numerous cultures have existed throughout human history whose roots were in the production of wine. Many individuals still believe that wine and culture go hand in hand. The "birth" of a civilization and its culture would not take long in prehistoric times in regions where the climate was conducive to wine growing, and vice versa: Once that culture had emerged, its wealth and well-being would be strongly related to vine and wine. That's not a coincidence because wine growing necessitates settling down and giving up wandering activities. It may thrive in poor soil, providing crops and other cultivations with fertile ground. Winemaking requires specialized knowledge and techniques, while its commercial element requires transportation and knowledge of business operations, economics, and shipping—the exchange of wine between civilizations created pathways for

disseminating intellectual and theological ideas throughout Europe.

1. WINE'S HISTORICAL PROGRESSION

Now let's fast-forward to the Predynastic period of the Egyptian Pharaohs, when wine was becoming increasingly popular across the ancient world [23]. According to hieroglyphics from this period, the Pharaohs didn't appear to worry as much about the quality of their drinking as they did about quantity. This suggests that binge drinking may not be such a recent coner [19]. However, the wine the Egyptians consumed was not related to the wine we consume today. Along with figs, palms, dates, and pomegranates, they also employed white, pink, green, crimson, and dark blue grapes. As you may assume, the flavor would have been quite different from what we consider wine now. The process of making wine from other fruits is similar to that of grapes, with the exception that sugar is added [25]. The Bible regularly refers to wine, from Jesus to Noah and his grapevines [19]. More specifically after the Flood, according to the Old Testament book of Genesis, chapter nine, verses 20–21, Noah planted grapevines and created wine [31].

Our oldest cultivated plant is the grapevine. The earliest pharmacopeia in the world, the Babylonian Nippur tablet (about 2200 years B.C.), has references to the use of ointments containing wine to treat skin disorders. Wine and mixtures blended with wine are advised against asthma, constipation, and dyspepsia, in addition to the treatment of epilepsy, and interestingly for the prevention of jaundice, according to the Egyptian Ebers Papyrus (1500 B.C.) [22]. The latter can be read as saying that drinking wine without any virus instead of water that was tainted with hepatitis virus could avoid the infectious (A and E) hepatitis under unhygienic settings. In the Gilgamesh

epic, the god Utnapishtim advises survivors to grow grapevine after the flood (3–4000 B.C.). Wine was used by Jacob to tamp down Isaac's attentiveness, and according to King Solomon, wine is the second-greatest human pleasure. But Isaiah takes issue with people who drink continuously from sunrise to sunset. The earliest indications of wine as we know it now were discovered at the northern Zagros Mountains' Hajji Firuz Tepe archaeological site in Iran. The area was Neolithic in age, dating from 8500 to 4000 B.C. According to carbon dating, the wine is between 5400 and 5000 years old [16]. The ability to make wine is said to have started around 6000 B.C. when humans domesticated plants and animals to build the first permanent communities. However, wine from earlier times is still undiscovered. The use of wine and alcohol throughout antiquity is covered in several facts. According to Sir John Malcolm (1789–1833), the oldest reliable historical record of the production of the noble liquid made from wine dates to the era of Persian culture. This hypothesis is supported by the Damascene cup that was used to store grape bunches [11].

2. GREECE'S ANCIENT WINE CULTURE

The Greeks were the next group to continue this enormous trade [27]. While viticulture appears to have flourished as early as the Neolithic era, 6,500 years ago, the history of wine in Ancient Greece is first documented in the 15th century B.C. Wine was a gift from nature that the ancient Greeks discovered and transformed into a work of art.



Fig. 1. Hercules is presented with wine in this representation of a scene from his Twelve Labours [21].

Wine has always been intricately linked to Greek cultural memory and, most likely, has been engraved into the Greek DNA in Greece [6]. From prehistoric times to the present, wine has been a part of Greek daily life as a supplement to nourishment, as a component of religion, or just for sheer enjoyment [27]. Greek culture and wine grew together to become rare gems that altered the path of human history forever. Dionysus and Ariadne's offspring, Staphylos and Oenopion, are credited with creating wine. According to a different story, Staphylos, a shepherd by profession who worked for King Oineas, observed that a goat's happiness and energy levels increased after it consumed the fruits of a certain plant. After tasting the juice, Oineas honored himself by

renaming the fruit Staphylos (Greek for "staph") and the juice (wine) "oinos" (Greek for "Oineas"). It's also said that Dionysus had a close friend named Ambelos who helped him remain upright while he was drunk. Zeus, however, was encouraged by Dionysus when he was still a young man and transformed him into a plant [3,12]. The symposia were the most well-known social gatherings throughout antiquity. The Greeks drank alcohol before symposiums, which were meetings when prearranged philosophical issues were debated, to aid in clear thinking. Greek art and ceramics depict these social gatherings in a variety of ways. The Symposium of Xenophon and the Symposium of Plato are two texts that provide instances of discussions that took place at symposia. Modern wine culture also started to form in ancient Greece when wine was no longer primarily consumed as part of religious ceremonies (as it had been when vineyards were possessed by priests and monarchs) [5]. While Christianity, as practiced by the Greeks of Byzantium, first opposed old Greek culture, it finally came to recognize and do more than any other method to propagate two ancient Greek values: the ancient language and the great winemaking tradition of Greece. The Greeks were aware of the health advantages of wine use, which is still an acceptable justification today. With their abundance of symbolism and allusions to vine and wine, Byzantine culture and Christian Orthodox art eventually came to represent Greece [6]. The symbolism is preserved in mosaics, religious icons, monastery scrolls, folk art, and demotic chants. Famous Byzantine wines from the Aegean Sea and other regions of Greece were deserving representatives of a civilization that for years shined like a beacon onto the West, penetrating the gloom that enveloped medieval Europe [16, 24] "Wine is the best medicament, if it is lacking, there may be a need for medicine," says the three-and-a-half-millennium-old Talmud. Hippocrates, the eminent physician of ancient Greece (460–370 B.C.), advocated the use of wine for a variety of medicinal uses, including diuretic, purgative, sedative, and wound healing. The deity of wine in Greek mythology was named Dionysus.

However, Greek culture and wine did not just have an impact on Greece. The legendary Greek wines were also adopted or utilized by those who would invade the land as conquerors, either violently or peacefully, to develop their civilizations and achieve reputation and wealth [12]. Apart from the highly esteemed wines produced by the Greek vineyards, the Roman civilization also adopted many of the nation's agricultural and winemaking techniques. To placate his generals, it is said that Caesar gave them fine Greek wines. By taxing the renowned Greek wine production or just by living side by side with the Christian Greeks who had not lost their "wine" instinct or genes, the Ottoman Empire amassed wealth, while as early as the Middle Ages, the Venetians, and other European seafaring powers used Greek wines as their main source of income when sailing worldwide. Thankfully, during their 400-year history, the monks in Greece managed to maintain their expertise. Then, Greece gained its independence in 1821. During the Middle Ages, spiced wines were produced in the wine regions of Germany, France, and Italy; but, from the latter part of the eighteenth century, Turin, Italy, emerged as the primary manufacturer of these products. Vermouths are created by

adding plant-based substances to base wines that can be used as food additives or to make alcoholic extracts [12].

3. GREECE'S MODERN AND PRESENT WINE HISTORY

The growth of raisins is characterized as taking place between 1821 and 1860. Having cultivation centers in Ithaca, Kefalonia, and Zakynthos, Greece is the global leader in this field. Between 1861 and 1911, there was a rise in the growing of grapes, but raisins remained the favorite fruit. In 1878, the phylloxera plant louse devastated France's vineyards, leading the country to import massive quantities of dried grapes from Greece for the production of dry-cured wine. After the French vines recovered, it became illegal to import raisins in order to sustain French wine production. This led to the 1893 sultana crisis, a sharp decline in prices, surplus stock piling up in warehouses, and the beginning of the wave of mass immigration to the United States [4].

Phylloxera was prevalent throughout Greece's ten-year period of war (1912–1922), which dramatically reduced productivity. Between 1928 and 1938, the years between the wars, there was a steady increase in grape farming. The locations that saw expansion were Sterea Hellas, more precisely the Mesogeion neighborhood of Attica with the winery of Andreas Kampas, and the Peloponnese, namely Achaia with the winery of Achaia Claus. The increasing number of people living in Athens has made them search for cheap bulk wine [3].

Since vinification happened in Athens bars rather than at wineries and no one could verify whether the must originated in the Attic vineyard or anywhere else, the reputation of Attica wine was tarnished as the vineyard grew. Greek wine producers have been relentless in their efforts, especially after 1980, and as a result, Greek wines are presented at international fairs, get international honors, and make their hesitant debut in other markets [27]. After 1995, the number of wineries increased and the foundation for building a powerful brand identity for Greek wine is laid.

4. EUROPE'S WINE INDUSTRY

The European Union is the world's biggest producer, consumer, and exporter of wine. Spain, France, and Italy together produce half of the world's wine production, and collectively they produce three-quarters of the EU's wine. By 2020, there will be 2.2 million hectares of vineyards in the EU, with an average size of 0.2 hectares in Romania and larger vineyards measuring up to 10.5 hectares. Additionally, 48% of the world's wine was consumed in the EU in 2021, with Germany, France, and Italy having the greatest average consumption. Global wine consumption is exceeded only by the United States by the combined consumption of these three countries [9].



Fig. 2. Annual European Wine Sales. Even for months before 1/02/2020, when the UK was still a Member State, the chart shows trade numbers for the EU without including the UK in its membership [8].

Due in large part to strong US consumer demand, wine exports from the EU increased in 2021–2022 to an unprecedented level of 34 million hl (+6% year over year, +10% compared to the 5-year average). In terms of value, the US, UK, China, and Canada are expected to be the top export destinations. Compared to the same period in 2020–21, the volume and value shipped during the first five months of 2021/22 have continued to rise [8]. The US and the UK continue to be the EU's top import destinations, accounting for 22% and 26% of volume and value, respectively. Exports to the US and the UK increased by 14% and 10%, respectively, over the same time in 2023[1].

5. The area of Greek winemaking

The bulk of Greece's wine industry consists of small and medium-sized enterprises, less large corporations, and agrarian cooperatives. Greece exports commodities to France and Germany, which make up 49.7% and 13.2% of the entire amount our country sends outside, respectively. After 2010, the average annual production decreased by over 20% [25]. Between 2014 and 2018, the Ministry of Rural Development and Food contributed 44 million euros for the establishment of vineyards, the addition of new grape varieties, and the enhancement of management practices to increase the competitiveness of the Greek wine market and increase the volume of high-quality wine exported to other nations. Between 2015 and 2018, 16 million euros were donated to support Greek wine promotion through US campaigns and events. In Greece, about 700 wineries and other businesses in the industry are allowed to operate lawfully. These wineries produce about 4000 Greek bottled wines.

Wine growers in the EU today face several challenges. Apart from the disruption caused by the COVID-19 pandemic to the hotel sector, adverse weather patterns resulting from global warming have also affected the wine industry, and it is anticipated that considerable adjustments to the wine-making process would be necessary[28]. The global wine market becomes more competitive, and consumers are favoring wines with lower alcohol levels and wine made and packaged sustainably. The changing regulatory landscape in the EU and at the national level presents new challenges [9].

6. THE WINE INDUSTRY'S DETRIMENTAL EFFECTS ON THE ENVIRONMENT

Notwithstanding these challenges, there is currently a 243-million-hectoliter global market for wine as an alcoholic beverage. As of right now, the cultivation and harvesting of grapes generates up to 5 tones of solid trash per hectare annually. Despite the winery's reputation for being ecologically beneficial, wine grape cultivation and wine production have been connected to a variety of environmental problems [17]. The production of significant volumes within a short time of the year (August to October) is one of the major environmental issues associated with the management of winery and distillery wastes report that the wine-making process leaves behind a range of residues, several of which contain notable amounts of biodegradable compounds and suspended particles [20]. To sum up, the residues consist of the plants that remain after the grapes are de-stemmed, the sediments collected during the clarifying process, the bagasse collected after pressing, and the lees collected after different decanting techniques. Grape pulp, skins, seeds, and dead yeasts used in the alcoholic fermentation process are all included in the waste from vinification lees [10].

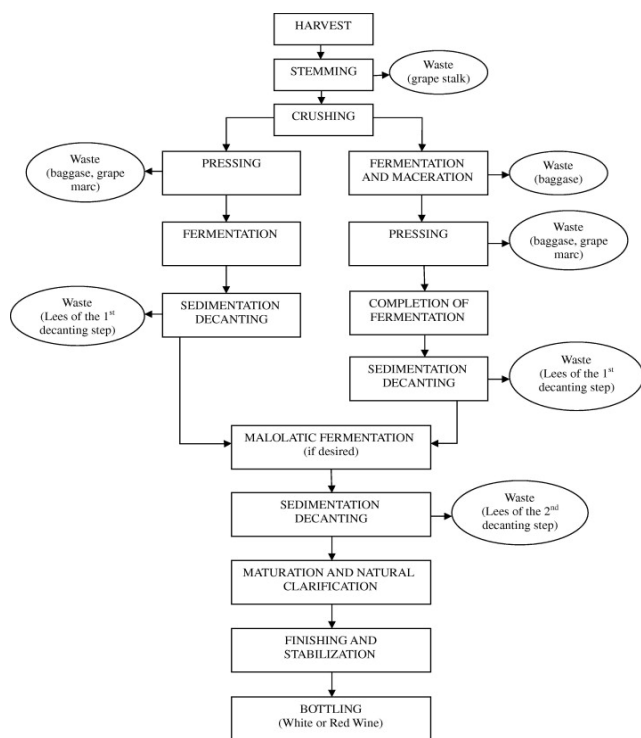


Fig. 3. Diagram showing the steps involved in making red and white wine [20].

Table 1. The Greek region's wineries

REGIONS OF GREECE	NUMBER OF WINERIES
REGION OF EASTERN MACEDONIA AND THRACE	39
REGION OF CENTRAL MACEDONIA	132
REGION OF WESTERN MACEDONIA	33
EPIRUS REGION	4
THESSALY REGION	43
IONIAN ISLANDS REGION	27
REGION OF WESTERN GREECE	42
REGION OF MAINLAND GREECE	56
REGION OF ATTICA	50
REGION OF PELOPONNISOU	140
REGION OF NORTH AEGEAN	22

Before being dumped in landfills and wastewater streams, this waste needs to be treated and valorized to ensure the least amount of environmental damage [2,29]. Every year, the EU produces 2.2 billion tones of waste. More over a quarter of it (27%) is municipal rubbish, or ordinary trash that is mostly produced by homeowners and is collected and managed by municipalities [29]. As we meet important social objectives, the circular economy provides us with the means to work together to address climate change and biodiversity loss, including the revaluation of trash. Wine manufacturing generates a lot of garbage, which annually presents problems for producers [18]. This is why appropriate management and valuation of vineyard wastes are crucial, despite their being difficult. This is because grape marc, which is thought to be a contaminant of the environment, is hard to remove. In the past, paying a fee of about EUR 3000 was the least expensive option for getting rid of this trash, but as of late, that cost has increased to EUR 30,000–40,000 [15].

7. CIRCULAR ECONOMY

Current global problems including climate change, land degradation, and ecosystem degradation, together with an increasing demand for food, feed, and energy, drive us to search for new ways of producing and consuming as well as disposing of waste and leftovers. Food waste is a major issue that both wealthy and developing countries are currently facing. Food waste is defined by Garcia-Gonzalez as the leftovers from different food processing industries that haven't been recycled or used for other purposes. These finished commodities are thrown away as trash because the expense of recovery is higher than their economic value [7]. Data show that, despite a trend towards more recycling and decreased landfilling, the amount of waste and the methods used to manage it vary greatly throughout EU countries [28]. In an attempt to reduce waste and its detrimental impacts on the environment, the EU has set high goals for recycling and landfilling, with a particular emphasis on packaging waste.

Encouragement of the shift to a more sustainable economic model—the circular economy—is the goal [30]. Harvesting or processing wastes are typically returned to the soil in order to recycle carbon and nutrients into agricultural soils. Research has been done on feeding winery co-outputs to farm animals and (vermi) composting winery co-outputs to create soil improvers [26].

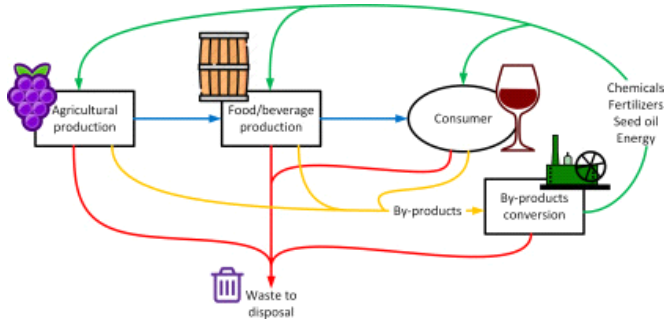


Fig.4. Waste formation during winemaking [13].

To maximize the use of this resource, however, changes in EU legislation have resulted in a reduction in the subsidies provided to distilleries. Winery waste and by-products contain several value-added compounds that have a great deal of potential to be recovered and used in various applications. The study of these "wastes" has been made possible by recent developments in contemporary chemistry and biotechnology, academic awareness, and industry interest. New technologies are constantly being proposed, not only for their reuse in agriculture but also for the production of common and innovative products for other industries, such as compost, animal feed and supplements, nutritional supplements, biofuel and fuel additives, in addition to other forms of bioenergy and platform chemicals. The circular economy may lead to the creation of a new economy and a new way of utilising, consuming, and producing products. The goal of the circular economy is to create a zero-waste system where resources are continuously moved from producers to consumers, a highly productive system in terms of the environment and economy [14].

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