Professional Internship Report

Study on Georgian winemaking. Focus on Qvevri wines

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Abstract

The following Professional Internship Report, within the MSc. in Viticulture and Enology (Vinifera EuroMaster), concerns a professional internship developed on the topic of Georgian winemaking, with focus on Qvevri wines, supported by Erasmus+ traineeships programme. During the internship period, from March to June 2020, the practical work was carried out at several wineries located in Georgia.

The report aims to present the observations and conclusions regarding: (1) Georgian wine and viticulture sector; (2) research on Georgian wine oenological and chemical profile; (3) current position of the Georgian wine sector on the market.

Archeological excavations traced the first wine evidences to Georgia, in 6000 B.C., positioning the country as the “cradle of wine”. The use of qvevris, Kakhetian winemaking method, the 525 grape varieties collection, has attracted attention on Georgian wine sector. Despite the growing interest, there are few studies researching particularities of Georgian wines.

According to the scientific literature, compared to the conventional wines, the red qvevri wines have a similar total phenolic content, while the white qvevri wines, due to the prolonged skin maceration of up to 6 months, have 5-10 times greater total phenolic content. The mineral composition of the qvevri wines is within the normal range of values. Regarding the classical oenological parameters, the only unusual observations are recorded for the high pH values.

The Georgian wine sector is passing through a period of adaptation and modernization. In the last years, it was recorded an increase in production and export. The wine production increased 2.3 times from 2010 until 2019, and in the first 9 months of 2019, 65.2 million bottles of wine have been exported to 53 countries.

Georgian wines represent both a product seeked by wine enthusiasts and a model that could provide valuable insight regarding the potential of national grape varieties and winemaking practices.

Key words: Georgian wines, qvevri, Kakhetian fermentation method, prolonged maceration, amphora wines

Resumo

O presente relatório realizado no âmbito do MSc. in Viticulture and Enology (Vinifera EuroMaster), refere-se a um estágio em contexto empresarial desenvolvido sobre a produção de vinho na Geórgia, e em especial dos vinhos Qvevri, suportado pelo programa Erasmus+traineeships. Durante o período de estágio, de Março a Junho de 2020, o trabalho prático foi realizado em diversas Adegas localizadas na Geórgia.

A seguinte tese tem como objetivo apresentar as observações e conclusões sobre: (1) sector vitivinícola Georgiano ; (2) perfil enológico e químico do vinho da Geórgia; (3) posição atual do setor vitivinícola da Geórgia no mercado.

Escavações arqueológicas rastrearam as primeiras evidências de vinho na Geórgia, em 6000 a.C., posicionando o país como o "berço do vinho". O uso do qvevris, método de vinificação Kakhetian, a coleção de 525 variedades de uvas, atraiu a atenção do mundo para a vitivinicultura na Geórgia.

De acordo com a literatura científica, em comparação com os vinhos convencionais, os vinhos tintos qvevri têm um conteúdo fenólico total semelhante, enquanto os vinhos brancos qvevri, devido à maceração prolongada da película até 6 meses, têm um teor fenólico total 5-10 vezes maior . A composição mineral dos vinhos qvevri encontra-se dentro da gama normal de concentrações. Em relação aos parâmetros enológicos clássicos, as únicas observações incomuns foram registradas para os valores de pH elevados.

Nos últimos anos, foi registrado um aumento na produção e exportação. A produção de vinho aumentou 2,3 vezes entre 2010 e 2019 e, nos primeiros 9 meses de 2019, foram exportadas 65,2 milhões de garrafas de vinho para 53 países.

Os vinhos da Geórgia representam um produto procurado por entusiastas do vinho e um modelo que pode fornecer informações valiosas sobre o potencial das variedades nacionais de uvas e práticas de vinificação.

Palavras-chave: vinhos da Geórgia, qvevri, método de fermentação Kakhetian, maceração prolongada, vinhos de ânfora

Resumo Alargardo

O presente relatório realizado no âmbito do MSc. In Viticulture and Enology (Vinifera EuroMaster), refere-se a um estágio em contexto empresarial desenvolvido sobre a produção de vinho na Geórgia, e em especial dos vinhos Qvevri, suportado pelo programa Erasmus+traineeships. Durante o período de estágio, de Março a Junho de 2020, o trabalho prático foi realizado em diversas Adegas na Geórgia. As principais operações incluíram a trasfega do vinho do qvevri e a limpeza dos vasos. Como o trabalho foi executado ao lado dos produtores de vinho locais, foi possível recolher informações valiosas sobre as práticas regionais de produção de vinho.

Escavações arqueológicas traçaram as primeiras evidências de vinho nas regiões da Geórgia. Nomeadamente, os sinais químicos de compostos orgânicos antigos absorvidos nos potes de cerâmica, como sais de cálcio, grainhas, ácido tartárico e ferramentas de vinicultura, datados de 6000-5000 A.D., posicionam o país como o “berço do vinho”.

As tradições únicas da vinificação, como, o uso do qvevris, o método de vinificação Kakhetian, a coleção de 525 variedades de uvas, atraíram atenção especial para o setor vitivinícola da Geórgia. Apesar do crescente interesse, há poucas pesquisas investigando as particularidades dos vinhos da Geórgia.

Como conseqüência, o principal objetivo do relatório a seguir é apresentar informação e conclusões sobre: (1) sector vitivinícola Ggeorgiano de vinho e viticultura; (2) estudos de pesquisa do perfil enológico e químico do vinho da Geórgia; (3) posição atual do setor vitivinícola da Geórgia no mercado, com base na análise da literatura existente

As pesquisas existentes destacam as particularidades interessantes da maceração prolongada da película e do envelhecimento em ânforas, especialmente no caso dos vinhos brancos, e fornecem uma visão dos possíveis resultados do vinho produzido seguindo o método Kakhetian. De acordo com a literatura científica, os vinhos tintos qvevri têm um conteúdo fenólico total semelhante ao tipo convencional de vinhos tintos (2,89 - 4,41 g de ácido gálico / L e 1,63 - 2,34 g de ácido gálico / L, respectivamente). Os vinhos brancos qvevri, devido à maceração prolongada da película e graínhasle por até 6 meses, apresentam entre 5 e 10 vezes maior conteúdo fenólico total que os vinhos brancos convencionais (1,33 - 2,43 g de ácido gálico / L e 0,21 - 0,46 g de ácido gálico / L, respectivamente). O extenso período de maceração de vinhos brancos, resulta em vinhospoderosos e estruturados, chamados *vinhos âmbar*. O intenso aroma e perfil tânico desses vinhos pode ser demasiado marcante e estranho para a maioria dos

consumidores. No entanto, esse problema pode ser superado aumentando a conscientização e oferecendo explicações básicas, essenciais para educar os consumidores inexperientes.

A composição mineral dos vinhos qvevri estudados encontra-se dentro da gama normal de valores, o que poderá ser explicado pelo revestimento utilizado, pois as paredes internas do qvevris são cobertas com cera de abelha, o que impede a lixiviação mineral. Em relação aos parâmetros enológicos clássicos, de salientar os valores de pH elevados os únicos valores incomuns foram os altos valores de pH registados (3,8 para vinhos brancos e 3,7 para vinhos tintos qvevri), o que poderá ser explicado pelas macerações prolongadas.

No entanto, no momento, não está claro qual a importância do uso específico de qvevris nas particularidades do vinho ouo tempo de maceração prolongado e a micro-oxidação que ocorre no qvevris desempenham o papel principal nas características do vinho.

A questão principal permanece enquanto todos os aspectos cumulativos do uso de qvevri oferecem aos vinhos características especiais, que não podem ser reproduzidas de outra maneira. Felizmente, mais estudos responderão a essa pergunta.

Os dados que analisam o setor vitivinícola da Geórgia no mercado mostram que a indústria vinícola da Geórgia está a passar por um período de adaptação e modernização. O forte apoio do governo visa reduzir os efeitos negativos da indústria altamente fragmentada, fornecer ferramentas para a modernização e aumentar a conscientização da marca sobre os vinhos nacionais. Nos últimos anos, foi registrado um aumento na produção e exportação. Nomeadamente, a produção de vinho aumentou 2,3 vezes entre 2010 e 2019, enquanto os registros de exportação mostraram que, nos primeiros 9 meses de 2019, 65,2 milhões de garrafas de vinho foram exportadas para 53 países, 10% mais garrafas do que no mesmo período em 2018.

O comércio de vinho tem-se intensificado particularmente nos EUA, China e países da UE. A Geórgia revela esforços contínuos para obter um lugar sólido no mercado internacional de vinhos. Se houver um investimento contínuo em redes de reconhecimento e distribuição de marca, isso poderá gerar um aumento no conhecimento dos vinhos da Geórgia e nas suas vendas.

O ressurgimento dos vinhos da Geórgia no mercado internacional coincide com o surgimento de uma nova geração de consumidores de vinho, que tende a ser mais experimental e focada nos valores emocionais, inovadores e educacionais dos produtos.

Considerando tudo o que foi mencionado acima, os vinhos da Geórgia representam um produto exigido e um modelo, que pode fornecer informações importantes e valiosas sobre o potencial das variedades nacionais de uvas e práticas de vinificação.

Table of Contents

List of Figures, Tables and Abbreviations

List of Tables and Abbreviations

PDO: Protected Designation of Origin
TPC: Total phenolic content
TA: Titratable Acidity
VA: Volatile Acidity

1. Introduction

Georgia, a former Soviet republic, situated in the mountainous slopes of the Caucasian Mountains, at the intersection of Western Asia and Eastern Europe, has had a pronounced relationship between its population and vine growing since ancient times. Both vine and wine held predominant roles religiously, politically and socially throughout the Georgian history.

Firstly, as in most Christian countries, the wine was associated to the blood of Christ. This leaded to an intense integration of viniculture in the culture and traditions of the country (Kharbedia, 2015).

Secondly, the viticulture and wine culture evolved in a parallel manner to the state power. Namely, the cultivation of vines reflected the establishment and growth of a region. As viticulture played an important role in maintaining the political unity supporting the administration in diplomacy and trade, it often benefited of the lasting support from the state authority, either that being royal or governmental. On the other hand, the invasion of the Georgian lands by its non-Christian neighboring countries was concluded, most often, by the removal of vines, as vineyards were symbol of the country's polity (Shtaltovna and Feuer, 2019).

Thirdly, wine holds a strong place in the social life of the Georgian population. Celebrations, hospitality and social gatherings often include events involving toasts managed by a toastmaster called *tamada*. Moreover, the population in rural area produce wine and celebrate the harvest (Shtaltovna and Feuer, 2019).

The development of viniculture on the territory of the modern Georgia began during the Neolithic period, around 6000 B.C., which suggest that there originated the first initiative of grape domestication and viniculture (Kharbedia, 2015).

In 2017 a three years old study, conducted by researchers from seven countries confirmed that Georgia is the birthplace of wine. The chemical signs of ancient organic compounds absorbed in the pottery jars, dated to 6000-5000 BC, indicate that the people of Gadachrili Gora and Shulaveris Gora were the first winemakers (McGovern et al., 2017).

Previous excavations disclosed traces of deposits of calcium salts, grape pips, tartaric acid and tools such as qvevri vessels and knives for trimming vines, dating back to 4000 BC, which indicate the advanced vineyard and winemaking work for that period (Odisheli, 2019; Kharbedia, 2015). The rich collection of more 525 native Georgian varieties and their genetic structure, which share connections to the Western varieties and regional wild grapevine germplasm further support the country's position as the birthplace of wine (Cola et al., 2016).

Since the recognition of Georgia as the “cradle of wine”, the country is establishing a strong position on the international wine market. The unique winemaking traditions, namely, the use of buried qvevris, the collection of over 500 native grape varieties, the particular production techniques and the distinctive wines full of character all lead to an increasing gain in popularity among wine researchers and enthusiasts.

Moreover, due to the low intervention during the winemaking process and the minimal use of additives and/or processing aids, like commercial yeast, finning and stabilization agents, qvevri wines share similarities with organic, biodynamic and “natural” wines. Consequently, qvevri wines represent not only a promising demanded product, but also a model, which could provide a valuable insight with regard to a “natural” winemaking method.

All the above considered, my professional curiosity and interest towards qvevris and towards minimal intervention wines leaded me to seek for an internship in Georgia. As the internship was carried on during the spring period, when there is limited winemaking work to be done and when the wines are racked off from the qvevris, I have decided to collect information from wineries of different sizes and located in various regions, rather than work in one single winery (Annex 1).

Therefore, the aim of the following thesis was to explore the rich culture of Georgian winemaking, presenting in a concise manner an overview of the main Georgian wine regions, grape varieties and winemaking practices. Moreover, the report will provide with a detailed description of the qvevri vessels and current research results regarding qvevri wines.

Finally, the literature analysis was supported by a record of collected information from various wineries, allowing for an insight of the current use of qvevri vessels in small, medium and large scale wineries.

2. General overview on Georgian vitiviniculture

2.1 Location

Georgia is located in the mountainous Caucasus region of Eurasia. The country is surrounded to the west by the Black Sea, to the north by Russia, to the south by Turkey and Armenia, and to the southeast by Azerbaijan. Georgia is situated between latitudes 41° and 44° N, and longitudes 40° and 47° E. Due to its geographical position, orographic barriers and natural conditions, Georgia presents diverse climatic conditions and soil spectrum.

2.2 Climate

The Likhi Range separates the country territorially and climatically into two macro regions: eastern and western regions: Eastern and Western Georgia.

The Western plain is characterized by humid subtropical maritime climate, with mild and rainy weather, accounting for 1,000–4,000 mm annual precipitation, mainly due to the air masses entering from the West, which crossing the Black Sea, accumulate substantial moisture, which induce great atmospheric precipitation (Matchavariani, 2019).

The East region is characterized by temperate continental, dry, subtropical climate due to the Likhi ridge, which blocks the passage of the humid air masses, the annual precipitation varying from 400 to 1600 mm annually.

The Caucasus mountains chain moderates regional climate by acting as a barrier against cold air currents from the north, setting subtropical climate in the South and temperate in the North.

The average annual sunshine duration is 1300– 2500 h (Matchavariani, 2019).

It is important to mention that every 3-4 years, droughts occur during the growing period. Another particularity are the hail storms, which can happen between 5 to 15 times per year (Gazadze & Nakashidze, 2014).

2.3 Viticulture Area

According to The National Wine Agency, there are ten distinct winegrowing regions: in Eastern Georgia - Kakheti, Kartli, SouthOssetia, Meskheti and Bolnisi-Marneuli; in Western Georgia - Imereti, Racha-Lechkhumi, Samegrelo, Guria, Adjara and Abkhazia (Figure 1).

These regions include 20 Protected Designation of Origin (PDO)'s: Akhasheni, Atenuri, Bolnisi, Gurjaani, Kakheti, Kardenakhi, Khvanchkara, Kindzmarauli, Kotekhi, Kvareli, Manavi,

Mukuzani, Napareuli, Saperavi Khashmi, Sviri, Teliani, Tibaani, Tsinandali, Tvishi, Vazisubani (https://www.winesgeorgia.com/site/overview).

The area covered by vineyards counts approximately 50,000 hectares.

Figure 1: Map of the Georgia's winegrowing regions

Source: LEPL National Wine Agency of Georgia

The main encountered challenges regarding viticulture are the serious fragmentation, with a proportion of about 70% of vineyards smaller than 0.5 hectares, and lack of modernization, which is translated to a lower yield of 5.1 tons/ha, representing, on average, half of the yield of the major European grape producers (Figure 2). However, large scale producers record up to 8.5 tons/ha (Kordzaia et al., 2020), indicating that the sparse plots integration, modernization and the revitalization of the vines can lead to a positive and promising outcome.

The average price of grapes in 2019 was around 1.11 GEL/kg (+0.9% YoY), which recorded a growth due to the increasing exporting demand (Kordzaia et al., 2020).

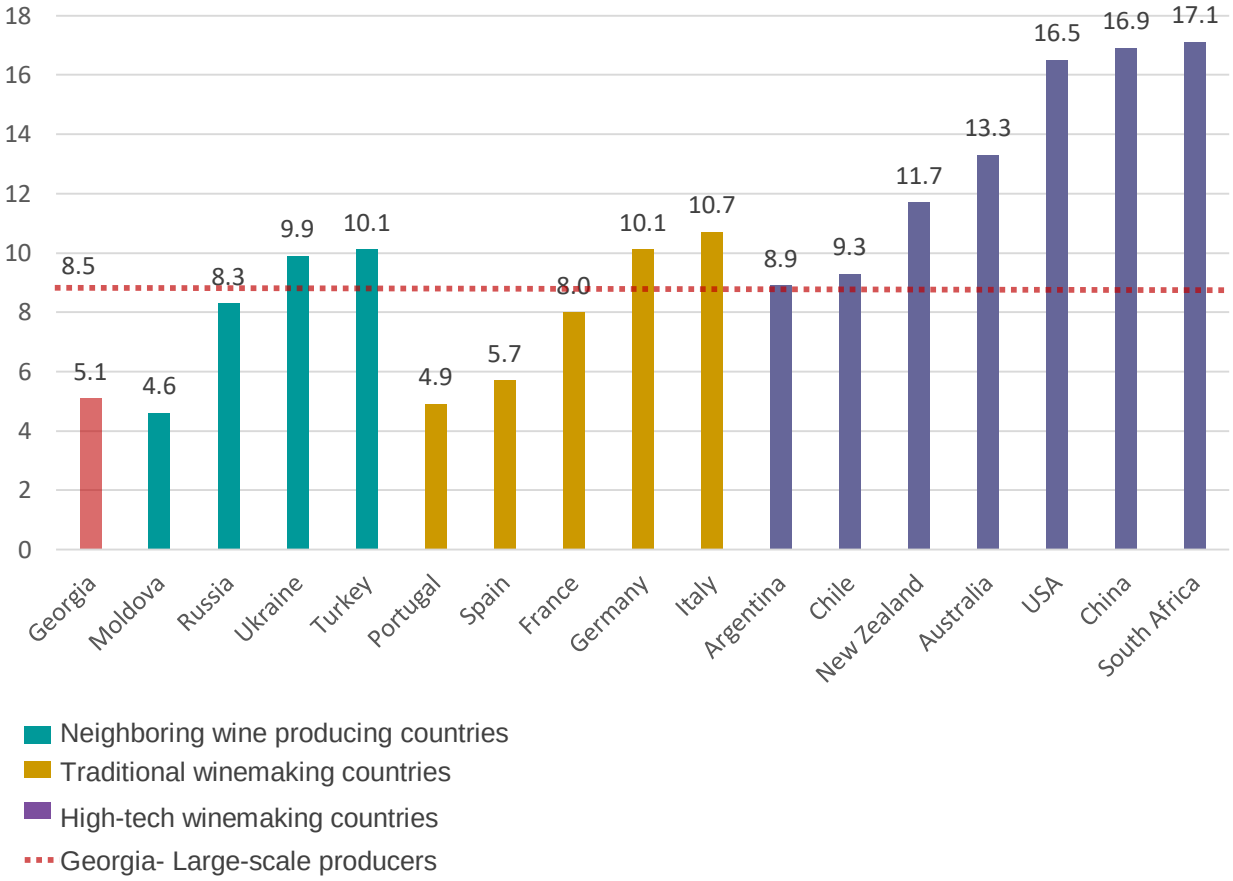


Figure 2: The average vineyard productivity of the main wine producing countries (Ton/ha), 2017

Source: Kordzaia et al., 2020

2.3.1 Main grape growing regions in Georgia

The six main grape growing regions in Georgia are: Kakheti, Kartli, Imereti, Racha, Meskheti and the Black Sea coastal zone. The distribution of the gape processing by region is illustrated in Figure 3.

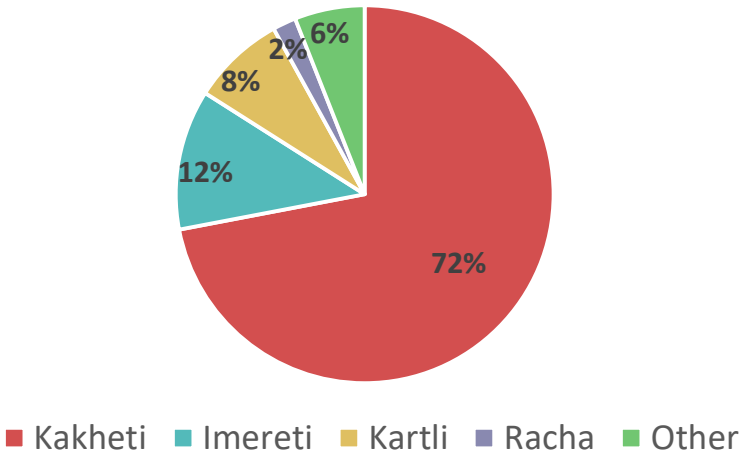


Figure 3: Share by region of total grape harvest, 2018

Source: Kordzaia et al., 2020

2.3.1.1 Kakheti

Kakheti is the most ancient and premier wine producing region in Georgia, covering an area of about 11,300 square kilometres and enclosing 15 out of the 20 wine appellations (Tsinandali, Gurjaani, Vazisubani, Manavi, Kardanakhi, Tibaani, Kakheti, Kotekhi, Napareuli, Mukuzani, Teliani, Kindzmarauli, Akhasheni, Kvareli and Khashmi) (LEPL National Wine Agency, n.d).

The region holds 73% of the country's grape producing and processing total (Bochorishvili et al., 2019).

Location

Kakheti lays in the South-Eastern part of Georgia, on the banks of Alazani and Iori rivers, on altitudes of 400-700 m above sea level. The North Eastern part is bordered by the ridge of Caucasus Mountains and the South-East is surrounded by Azerbaijan. Kakheti is divided by the Tsiv-Gombori mountain range into the Inner Kakheti to the east and the Outer Kakheti to the west of it (Sakpatenti, 2019).

Climate

Three agro-climatic zones can be observed in the region: subtropical, warm and moderately warm. The average annual rainfall can reach 600-800 mm. The temperature during summer average between +20 and +25 °C and in winter, between +2 and +4 °C. During the

growing season, the mean temperature is 18,5 °C. The sum of active temperatures is 3500-4000°C, while the sunshine duration can reach 2300 h.

One of the major adverse climatic problem occurring in the region is hailstorm in autumn and spring (Sakpatenti, 2019), which can cause irreversible damage in the vineyard by reducing the photosynthetically active leaf area, and a consequent low sugar accumulation or by physically damaging the berries (Keller, 2015). Another climatic risk factor are the long frosts, as temperatures can drop to -20°C (Sakpatenti, 2019).

The climatic conditions allow for overall good conditions for viticulture, without the need of investing in protection or irrigation.

Soils

The Outer Kakheti vineyards are located on the West side of the Tsiv-Gombori Range on 450-700 m above sea level. The soil type in the area is predominately black (Chernozem), with a pH of 7,3-8,2 and a humus content in the active layer varying between 2,5-25%. Meadow-brown soils are also widespread. There is a small area with alluvial and deluvial soil, which is carbonated and moderately alkaline (Sakpatenti, 2019).

Inner Kakheti zone includes the territories laying on left and right banks of the River Alazani and the North-Eastern and North-Western slopes of Tsiv-Gombori Range, on 350-750 m above the sea level. The typical soils found in the region are brown, meadow-brown and alluvial. The profile of the first two types of soils is characterized by a loamy and clay content, slightly carbonated with a pH of 7.2-8.2, a humus content is the active layer 30-60 cm of 2.0-4.0%.

The alluvial soils are located mainly alongside of the River Alazani and are characterized by a loamy and heavy loamy profile, with a humus content in their active layer of 1.5-2.5% and a pH 7.3-8.2 on right bank, and – 6.2-7.0, on left bank (Sakpatenti, 2019).

It is important to mention the presence of meadow cinnamonic type of soil, particular to the region. Their profile is characterized by a dark brown color, alkaline reaction, heavy texture, low-medium clay content, loose microstructure with complex, irregular aggregates and fragmental porosity (Matchavariani, 2019).

Vineyard Management

The vineyards in Kakheti are located on altitudes of 200-750 m above sea level. The common vineyard parameters are the following:

- Distance between the rows: 1 - 3 m
- Distance between the vines in one row: 0.8 -1.5 m;
- Height of trunk: 60-90 cm;

- Training system: single or double Cordon, Guyot, fan shaped, with numerous canes trained in one or two directions (Robinson & Harding, 2015) or similar local training systems known as Georgian one-sided, Georgian two-sided or free (having a fan-shaped form);
- Yield: 6-12 tons/ ha, depending on the grape variety and rules of appellations (Sakpatenti, 2019).

The regulations of vineyard management vary and depend on the rules of each of the 15 appellations included in the region.

Grape Varieties:

There are about eighty different grape varieties recorded in Kakheti. However, the main grape varieties cultivated in the region for red wines are: Saperavi, Tsiteli Budeshuri, Kharistvala, Gavazuri, Dampala and Cabernet Sauvignon.

For the production of the white wines: Rkatsiteli, Kakhuri Mtsvane, Kisi, Khikhvi, Mtsvivani Kakhuri and Chitistvala grape varieites (Ketskhoveli et al., 1912).

Grape processing

The Kakhetian winemaking involves the introduction of the crushed grapes and of the juice in the qvevris, which are placed underground, where the alcoholic fermentation takes placed, followed by the maturation, the whole process lasting up to 5-6 months (Tauchen et al., 2015). The grape processing regulations depend on each of the fifteen appellation legislation.

2.3.1.2 Kartli

Kartli is situated in the central Southern part of the country, neighboring Kakheti. However, the style of wines produced in the region evolved in a different direction. Namely, the predominant wines are high quality sparkling wines and wines produced following the European style. The two PDOs found in Kartli are Atenuri, producing white dry and sparkling wine and Bolnisi (Sakpatenti, 2019).

Location

The vineyards are situated in the basins of Mtkvari river, which crosses the region, on 450-700 m above sea level.

Climate

Kartli comprises various types of climatic conditions, from moderate humid in North and Center part to dry subtropics to moderate humid subtropics in the Eastern part of the regions.

The particular climate in the main grape growing area is subtropical with moderate humidity, hot summers and cold winters. The total sunshine duration reaches 2300 hours, from which, about 1500-1700 hours during the vegetation period. The average summer temperature is 22°C, while in winter can reach -1,5°C. The sum of active temperature is approximately 3450°C. The annual sum of atmospheric precipitations is 560 mm, with the highest predominance being in Mat (73 mm). In late spring, light hailstorms are common. (Sakpatenti, 2019).

Soils

The typical soils in the regions are light, dark brown with a higher salinity content and alluvial soils. In Atenuri, the soil pH varies between 7.2-8.2. Humus content in active layer ranges between 0.5-3.25%. The soil has a poor content of hydrolyzed nitrogen, about 0.6 mg/100 g soil (Sakpatenti, 2019).

As in Kakheti region, the meadow cinnamonic soils are distributed within the region (Matchavariani, 2019).

Vineyard management

The vineyards are situated in the basins of Mtkvari river, which crosses the region, on 450-700 m above sea level. In the Atenuri and Bolnisi PDOs, the following indications are imposed: the rows distance should be 1-2,5 m, while the distance between the vines 0.8 -1.5 m. The training system can be Georgian one-sided or two-sided or free. Generally, the vineyards can be irrigated during summer (Sakpatenti, 2019).

Grape varieties

The grape growers maintained the cultivations of local varieties like Chinuri, Gori Mtsvane, Budeshuri, Tavkveri, Shavkapito and Saperavi. However, the international varieties Aligote, Pinot Noir, Chardonnay, Sauvignon White, Merlot, Cyrano, Risling etc. can also be found.

Overall, the local Kartlian vine species share morphological and agricultural simmilarities with the grapes grown in Kakheti (Sakpatenti, 2019).

2.3.1.3 Imereti

Location

Imereti is situated Western Centre part of the country along the middle and upper banks of Rioni River. Due to its diverse climatic conditions and soil composition, the region produces various styles of wines.

Sviri PDO, the sole wine appellation in the region, is located on the left bank of Kvirila River, bordering the Northern and Southern Caucasus foothills, on 220 m above sea level (Sakpatenti, 2019).

Climate

As mentioned earlier, Imereti is characterized by various climatic conditions. Therefore, the following paragraph will focus on the Sviri PDO micro zone.

The climate in Sviri is coastal subtropical, relatively humid, with mild winters and hot summer. Annual sunshine duration can reach 2180 hours, from which, 1610 hours are during vegetation period. The average annual temperature is about +12°C. The sum of active temperatures is 3730°C. The average annual atmospheric precipitations is 884 mm, from which 662 mm occur during the vegetation period, with maximum rainfall being in May (150 mm) (Sakpatenti, 2019).

Soil

Due to the high diversity of the soils in Imereti, it would be inaccurate to name a dominant type of soil. However, the area presenting grape growing interest, which comprises Sviri appellation, has predominantly alluvial soils, comprising loam and clay. The soil is mainly characterized by a humus content of 2.5-1.5% and low hydrolyzed nitrogen and phosphorus content of 2.5 mg/100 g soil and 8.0 mg/100 g soil, respectively (Sakpatenti, 2019).

Grape varieties

The predominant varieties cultivated in Imereti are: Tsolikauri, Thiska, Krakhuna, Kvishkhuri, Dondghlabi, Bazaleturi, Kundza, Tklapa, Otskhanuri Sapere etc. (Sakpatenti, 2019).

Grape processing

The use of qvevris as part of the winemaking process is prevailing in the region. However, as opposed to the Kakhetian method, less must is left to ferment on the pomace (chacha) and the wine is kept in the qvevri for two months, which is less than the usual six months in Kakheti (Sakpatenti, 2019).

2.3.1.4 Racha

The particularities of Racha region are the small area covered by vineyards and the rare grape varieties. The two wine appellations found in the region are: Khvanchkara PDO and Tvishi PDO, which produces semi sweet, white wine (Sakpatenti, 2019).

Location

Racha is located in the Northern-Eastern part of the country. The vineyards are cultivated mainly on the slopes of River Rioni gorge (Sakpatenti, 2019).

Climate

The climate conditions are characterized by relatively high humidity, cold winters and warm, dry summers. The annual sunlight duration can reach 2000 hours, counting about 1500 hours during the vegetation period. The sum of active temperatures varies between 3350 - 3700°C. The annual rainfall is 1100 mm, from which, 650 mm are during the vegetation period (Sakpatenti, 2019).

Soil

The predominant soil type is humus-carbonated soil, with a moderately alkaline pH of 7.3-8.2 and loam and clay content (Sakpatenti, 2019).

Vineyard

The vineyards are located on a moderately inclined relief, exposed towards the South-East and East (Sakpatenti, 2019).

Grape varieties

The region holds rare grape varieties like: Tsulukidze Tetra and Tsolikouri, Aleksandrouli, Mudjuretuli, Rachuli Dzelshavi, Usakhelauri and Orbeluri (Sakpatenti, 2019).

2.3.1.5 Black Sea Coastal zone

The vineyards of Black Sea Coastal zone are located usually at 2-4 m above sea level, but can be planted on altitudes of 500 m above sea level, which brings humid air currents. The climate in the region is subtropical.

The most important winemaking regions are: Guria –Samegrelo, Abkhazia and Adjara.

The main grape varieties cultivated in the region are: Amlakhu, Avasikhva, Kaghighi, Agshibi, Akabuli, Absuaj, Lakoaj, Khapshira, Khunaliji, Tsolikouri, Ojaleshi, Chkhaveri and Krakhuna. In recent years, the grape growers focused on the restoration of ancient local grape varieties like Brola, Khopaturi, Klarjuli etc. The harvest starts late, in January and can be extened till January (LEPL National Wine Agency, n.d.).

2.3.1.6 Meskheti

Meskheti is distinguished by the most ancient sites of grae growing regions and the highest mountain viticulture territory, namely, at 900-1700 m above the sea level. Due to the inclined slopes, the vineyards are cultivated on stonewall terraces (LEPL National Wine Agency, n.d.).

2.4 The Wine Sector

In 2019, 245 wine companies were registered to be involved in the processing of grapes, and 1088 Georgian wineries have registered to be involved in wine commercialization.

In the vintage peak phase, daily processing number reached 12,000 tons, a record data for the last 30 years. As of October 1, 2019, 213 thousand tons of grapes have been processed in Kakheti region: 135 thousand tons of Rkatsiteli, 78 thousand tons of Saperavi, 5 thousand tons of Kakhuri Mtsvane and the rest of various grapes (LEPL National Wine Agency, Report III Quarter, 2019).

2.5 Main Grape Varieties

The particular complexity of the relief, soil and climate explains the evolution and diversification of the local group of vines. Currently, there are registered 524 aboriginal vine species, from which 248 are present in the country, while the rest are preserved in collections abroad (Chkhartishvili & Tsertsvadze, 2004).

According to Cola, 2016, the autochthonous Georgian varieties represent a great source of **biodiversity and a potential tool** for obtaining varieties resistant to environmental and climatic challenges.

Currently, about 40 varieties are used for commercial wine production, the most widespread being: Rkatsiteli, Goruli Mtsvane, Chinuri, Khikhvi, Saperavi, Tsolikouri, Alexandrouli, Mujuretuli, and others (Gazadze & Nakashidze, 2014).

According to Julius Kühn-Institut et al., 2012, the native cultivars cover about 95% of the total vineyard area. The proportion of the premier grape varieties in 2012 was Rkatsiteli B. (19,741 ha), Tsolikouri B. (6,161 ha), Saperavi N. (3,704 ha), Tsitska B. (2,839 ha), Chinuri B. (859 ha), Dzelshavi N. (685 ha). The black grapes share only about 16 % of the total cultivated varities while the rest are white.

Figure 4 presents the proportions of the main varieties cultivated in Georgia. Rkatsiteli and Saperavi count together approximately 90% of the total grape production in Georgia. Their

predominance is explained by their high resistance against grape diseases and unfavorable climatic conditions, ease of cultivation and quality of final wines. In the last years, however, it was observed a growing interest towards other local varieties as Kakhuri Mtsvane, Tsolikauri, Ojaleshi etc. (Kordzaia et al., 2020).

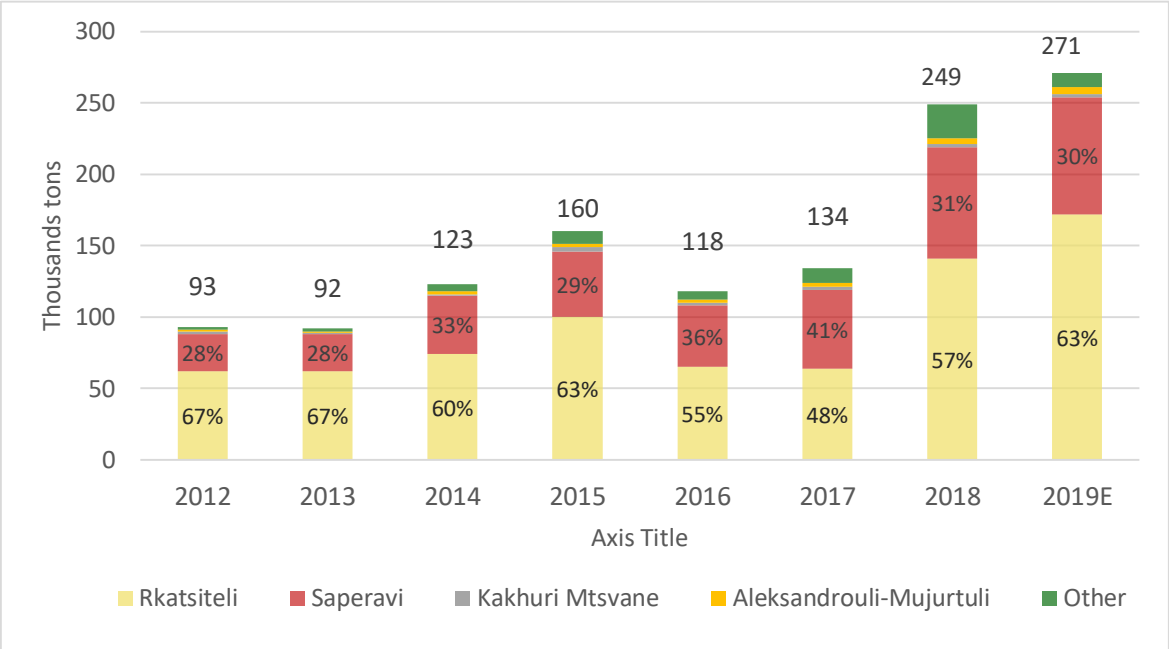


Figure 4 : Processed grapes (thousands tons), 2012- 2019E

Source: Kordzaia et al., 2020

Regarding rootstocks, according to Julius Kühn-Institut et al., 2012, the Phylloxera resistant rootstocks most suitable for Georgian soil conditions are the following: Kober 5BB, 420A, 41B, SO4, 101-14, 3309 Couderec, 3306 Couderec, Rupestris du Lot, Teleki 8B, No14 (Rkatsiteli X Riparia Gloire), No19 (Kharistvala Shavi X 420A) and No32 (Rkatsiteli X 420A) developed from national breeding programs.

The great diversity of the botanical and agricultural characteristics makes it impossible to provide with a precise and veritable overview of the grape species. However, bellow is presented a generalized description of the main Georgian grapes, for a better understanding.

White varieties:

1. Rkatsiteli

Rkatsiteli (Figure 5) is an ancient, white variety, originated in the Kakheti region that plays a central role in the Georgian wine production. Due to its high agro-technological qualities and great adaptability, Rkatsiteli is widely used for both European and Kakhetian style of wines (Ketskhoveli et al., 2012).

Botanical Description

The grape leaf is of medium size (19x18cm), round, 3 lobed (rarely 5 lobed), medium or slightly dissected, funnel-grooved. The petiole incision is deep, similar to a lyrewith a basis that is often sharp or roundish. The teeth at the ends of the blades are triangular, with slightly convex sides.

The bunch has a medium size (13-15 cm long, 7-8 cm wide), cylindrical-conical and cylindrical, medium-dense, with the mass averaging 155-165 g. The color is golden yellow and it has thin skin. Sometimes the berries turn slightly pink (Ketskhoveli et al., 2012).

Figure 5: Illustration of Rkatsiteli grape variety

Source: Ketskhoveli et al., 2012

Resistance

The significant resistance to fungal diseases and frosts and its ability to preserve acidity during the hot periods make Rkatsiteli a wide spread variety in the Eastern Europe and Caucasus region. It has a more endurance against downy mildew than against powdery mildew. In Western Georgia, it is less resistant to downy mildew than other species, which requires an additional fungicide administration. It is also relatively resistant to phylloxera (Ketskhoveli et al., 2012).

Agro-Biological Description

The period from the beginning of bud blooming to the full maturity of grape berries, usually lasts 155-160 days, accumulating a total of active temperature 2950-3000 ° C. Generally, the buds

open late (end of April), ripening occurs around mid October. The vines are characterized by high yiled. Productivity is high, but variable. The fertility of shoots is recorder to be 20-70% (Ketskhoveli et al., 2012).

Chemical Profile

Rkatsiteli can accumulate a large amount of sugar and keep the necessary level of acidity. The balance between these components make it successful for the production of a wide range of wine styles: table, sparkling, wines, fortified wines and brandies (Ketskhoveli et al., 2012).

Taste profile

When vinified according to the European method, Rkatsiteli can be described as refreshing, offering subtle floral aromas with citrus, white peach and apple hints. As a refrence, the wine could be compared with Petit Chablis or Pinot Grigio from northern Italy. The qvevri style wine is more intense and tannic and has a crisp acidity. The slight oxidative profile gives complexity and accentuates the honey, orange peel, spices and apricot aromas (Wine-Searcher, 2015).

Wine Production

In 2019, Rkatsiteli counted for about 63% of the total processed grapes. However, the proportion of the Rkatsiteli in the total grape harvest has decreased by 4% in the 2012-2019 period. (Kordzaia, 2020).

The grape is principally spread in Kakheti region and is often blended with 15-20 % Mtsvane Kakhuri, in Gurjaani, Tsinandali, and Vazisubani PDOs. As mentioned earlier, due to its resistance to frosts and high adaptability, there are important vineyard plantations in Armenia, Azerbaijan, Ukraine and Moldova (Ketskhoveli et al., 2012).

2. Mtsvane Kakhuri

Mtsvane (Figure 6) is another ancient yellowish-green coloured grape variety, originating in Georgia, which is widely planted across the country. Mtsvane gives high quality productions and thrives well in regions with humus-carbonate, alluvial-carbonate and alluvial-noncarbonate soils (Ketskhoveli et al., 2012).

Botanical Description

The leaves have a medium size of about 18 cm and are colored dark green. It has rounded shape, with a wrinkled surface. The leaf, usually, has 5 lobes and the blades are funnel like cut. The incision of the petiole is normally closed, lyre-like.

The middle sized bunch measures about 12-17cm long and 9-15cm wide. Bunches, being quite dense, weight around 165-170g. The majority can be described as oval, middle sized, with thin skin. The color yellow-green, covered with waxy spots (Ketskhoveli et al., 2012).

Figure 6: Illustration of Mtsvane Kakhuri grape variety

Source: Ketskhoveli et al., 2012

Agro-Biological Description and Resistance

Mtsvane is a popular grapevine due to its high qualities and productivity, similar to Rkatsiteli and Saperavi. The grapevine has the advantage of being resistant to phylloxera, downy mildew and winter frosts. However, it is very susceptible to powdery mildew and general environmental conditions. Mtsvane has a high ability to accumulate sugar (Ketskhoveli et al., 2012).

Taste profile

Mtsvane is appreciated for its fine aromatic wines and is often used in blends, improving the quality of the wines (Wine-Searcher, 2015).

Production

Mtsvane is mainly grown in Georgia, covering about 0.5 % of the total cultivated vineyards, and can also be found in Ukraine, Crimea, Armenia and Azerbaijan. It is less popular, as consequence of its low resistance to powdery mildew and overall sensitivity to soils and climate condiions (Gazadze and Nakashidze, 2014).

3. Kisi

Kisi (Figure 7) is a white grape variety, believed to be a hybrid between Mtsvane and Rkatsiteli. According to its botanical and agro-technical characteristics, it shares similarities with other widespread varieties of Kakheti region, where is mostly distributed (Ketskhoveli et al., 2012).

Botanical Description

The leaves have an average size of 18.5 x 18 cm, with a roundish shape and dark green color. They are usually 3 lobed and have a rough like surface, covered with blisters. The upper incisions are superficial, with a closed oval shape. The shape of petiole incision is similar to the lyre or an arch. The lateral teeth are similar to a saw.

The size of the bunch is approximately 18x10cm, while the shape reminds of a cone. The medium sized berries are distributed quite densely and they have a yellow- greyish color, covered with thick waxy spots. The weight of a bunch averages 120 - 160 g (Ketskhoveli et al., 2012).

Figure 7: Illustration of Kisi grape variety

Source: Ketskhoveli et al., 2012

Agro-Biological Description

Kisi starts ripening early, which makes it suitable to be cultivated in cooler locations. Kisi requires systematic organic and mineral fertilizing (Ketskhoveli et al., 2012).

Resistance

Kisi is particularly resistant against downy mildew, while susceptible to powdery mildew. The grapevines also present resistance against frosts drought. However, it can be damaged by the black rot (Ketskhoveli et al., 2012).

Tasting profile

Kisi's aromas can be described as of ripe pear, marigold, tobacco, and walnut. The grape has great potential to produce semi-sweet and dessert wines (Ketskhoveli et al., 2012).

4. Chinuri

Chinuri (Figure 8) is another popular white variety, mainly cultivated in Kartli regions, where is believed it originated from.

Botanical description

The average leaf has a round form, of 16.5 - 17.8cm long and 16.4 - 17.5 cm wide size, with a bright green. The petiole's incision is similar to an arch, with a square basis. Normally, is three lobed, rather that five. The tip forms an obtuse angle to the blade and the teeth are wide triangular. The leaf has a smooth surface, while the underpart is covered with short bristles.

The bunch has a cylindrical shape and an average size of 17 – 18 cm long and 9 – 10 cm wide. The berries are also middle sized and oval, with the skin easily easily detachable from the pulp.

The bud break occurs during middle of April, while flowering at the beginning of June and is a late ripening variety (Ketskhoveli et al., 2012).

Figure 8: Illustration of Chinuri grape variety

Source: Ketskhoveli et al., 2012

Resistance

As opposite to Kisi and Mtsvane, Chinuri has a good resistance to powdery mildew and is sensitive to downy mildew. It was also recorded that in the regions where it was cultivated, it showed resistance to phylloxera. It gives particularly high quality yields in locations surrounding rivers, on south or south-eastern slopes, in soils rich in calcium carbonates and stones (Ketskhoveli et al., 2012).

Tasting profile

Chinuri's particular acidity and aromas of pear and mint makes it popular among sparkling wine producers.

Red grapes:

5. Saperavi

Saperavi (Figure 9) is teinturier variety produces high quality wines and is one of the most important varieties in the Georgian wine industry (Ketskhoveli et al., 2012).

Botanical description

The average size of the leaves is 22 x 20cm. The three lobed leaves has rounded, wide div ided, bright green blades. The incision of the petiole is similar to an arch. The surface can be barely covered with short bristles, while the underpart is thickly covered.

The bunches measure a medium size of 13 to 21cm long and 7.5 - 12cm wide, and they have a cone shape. The average weight is 150 g. The berries are also middle sized, of dark blue colour and covered with wax-like spots (Ketskhoveli et al., 2012).

Figure 9: Illustration of Saperavi grape variety

Source: Ketskhoveli et al., 2012

Resistance

Saperavi shows high resistance to both powdery and dowry mildew and to frosts. However, it is quite susceptible to other fungal diseases and can be easily damaged by phylloxera (Ketskhoveli et al., 2012).

Production

Saperavi was part of the standard assortment of the Soviet Union, when only a limited list of grapes were allowed to be grown. Currently is distributed in the Caucasus regions and mainly in former Soviet countries. In Georgia, it covers about 10% of the total vineyard area and in 2019 it counted 30% of the total wine production. Notable high quality wines produced solely from Saperavi are: Akhasheni, Mukuzani, Napareuli and Alazani (Ketskhoveli et al., 2012).

Taste profile

Saperavi wine offers aromas of dark berries, licorice, tobacco, chocolate and smoky notes, as well as rich and balanced taste, suitable for long period aging (Wine-Searcher, 2015).

6. Tavkveri

Tavkveri (Figure 10) is an indigenous red grapevine variety of Kartli.

Botanical description

The leaf size is about 21 cm long and 19 cm wide, with an oval shape. It has five lobes, the top margin creating an obtuse angle to the blade. Normally, leaf is flat or slightly curled. Both upside and downside are smooth and bare. The veins of the underside are clearly delineated of pinkish color. The petiole is bare and dark red.

The bunch has a cone-cylindrical shape with a length of 15 - 17cm, 11 - 12cm width. The berries are distributed densely on the bunch. The berries are dark blue and thick-skinned. The skin of the berry is covered with wax-like spots and is easily separable from the fruit. The fruit is juicy and slightly acidic (Ketskhoveli et al., 2012).

Figure 10: Illustration of Tavkveri grape variety

Source: Ketskhoveli et al., 2012

Resistance

Tavkveri is susceptible to fungal diseases, being particularly susceptible to downy mildew and gray rot. According to the observations, Tavkveri is both resistant to droughts and frosts. The grapevine has successful yields in regions with deep, clay and sandy soils (Ketskhoveli et al., 2012).

Production

Tavkveri is mostly cultivated in Kartli region. The wines are not suitable for ageing and are rather consumed young and fresh. The grapes can also be used for juice production.

7. Chkhaveri

Chkhaveri is red variety original from Guria region. The grapevine is currently grown mainly in the Western Georgia, near Black Sea (Ketskhoveli et al., 2012).

Botanical description

The mature leaf is about 17-18 cm long and 15-17 cm wide, it has a roundish form and bright green color. The tip margin forms a right angle to the blade. The teeth are triangular with rounded ends. The upper part of the leaf is smooth and flat, while the underpart is covered with bristles. The petiole is bare, of green or reddish color (Ketskhoveli et al., 2012).

The bunch is small sized (10 - 15cm long and 7 - 12cm wide), cone-cylindrical, sometimes with a wing. The berries have a dark red color, middle or small sized. The skin of the berry is thin, covered with waxy spots.

It is a late ripening variety, the phase lasting from end of August till beggining of November. The sum of active temperatures during the entire vegetation period is from 3879 to 4100°C. (Ketskhoveli et al., 2012).

Resistance

Chkhaveri is very susceptible to downy mildew and powdery mildew and prone to Botrytis infection.

3. Overview on Qvevri vessels

The qvevri vessels take a special place in the cultural identity of Georgia. The origin of the qvevri can be related to the beginning of winemaking, as the pots were used as fermentation and storage vessels. In 2013, UNESCO registered the Qvevri winemaking method on its List of the Intangible Cultural Heritage of Humanity (UNESCO Multimedia Archives, 2013.) .

At this date, qvevri wines account for about 10% of total wine production (Golysheva, 2019). However, since the rise in popularity of Georgian wines and of the overall tendency towards natural wines, qvevri wines are gaining special spotlight, which makes it essential to further study and collect information regarding their particularities.

The qvevris have a distinct shape with a pointed base and they can vary in size, from 20 to 5000 Liters (currently, the most popular sizes are the 1000-2000 Liters).

The egg shape of the vessels allows the seeds to sink first, which reduces the risk of harsh tannin extraction. Following, the skins and stems (chacha) form the second layer. As a result,

there is a rich, but balanced extraction and the wine has strong character due to the high amounts of polyphenols (Capece et al., 2013). Figure 11 presents the visualization of the cross section of the qvevri vessels.

Figure 11: Cross section of the qvevri vessel

Source: Gogo, 2016

As the qvevris are buried underground, they benefit from the consistent temperature, as opposite to the fluctuations that would occur in tanks, which is both financially and environmentally sustainable. However, it is possible to set an underground network of pipes, in order to flow cold water, when needed.

Another advantage of keeping the vessels underground is that the surrounding soil pressure the walls, reducing any explosion risk during fermentation (Barisashvili, 2011).

The cellar where the qvevries are positioned is traditionally called *marani* (Figure 12). Depending on the region, the marani can be closed or open. In the Eastern region, the qvevris are located inside the marani, which is built of stone. In the Western region of the country, due to the milder climate, the qvevri vessels can be buried directly in the courtyard "under a cloud", in this case, the site is called *chur-marani* (Domaine Georgia, n.d.).

Figure 12: Picture of the qvevri cellar (marani) at Bolero & Co winery

Manufacturing

The qvevri vessels are hand made from clay and fired in a ceramic furnace. The process of producing qvevris is very laborious and requires skill, experience and financial investment (Domaine Georgia, n.d.) .

Conventionally, before finishing, the exterior walls of the qvevris are coated with lime, which is resistant to mold and possesses antiseptic proprieties. Moreover, the lime layering ensures temperature preservation and reduces its fluctuations, which is especially advantageous during both alcoholic and malolactic fermentations.

Another particularity of these clay vessels is the use of beeswax to coat the interior walls. The beeswax fills a grand proportion of the pores, reducing the oxidation risk and also has antiseptic qualities (White, 2016).

Firstly, it is important to mention that the quality of wax is crucial. Beeswax containing paraffin or other foreign materials should be strictly avoided. Moreover, artificial honeycombs used by beekeepers, could contain paraffin, stearin and other additives which could contaminate the beeswax (Barisashvili, 2011).

In order to distribute the beeswax layer homogenously on the walls and to ensure its penetration into the pores and to prevent their cracking (as the melted beeswax can reach 120 ºC), the qvevris are heated at a weak fire, usually until the walls reach 70ºC. Traditionally, the pots are heated by setting a fire using dried vine stalks laid on a tin vessel , as the use of plastic, coal,

straw, coniferous material or petrol, diesel and kerosne fuels is not advised. Although natural gas did not appear to impair the quality of wines or damage the qvevris, its usage has not been as common (Barisashvili, 2011).

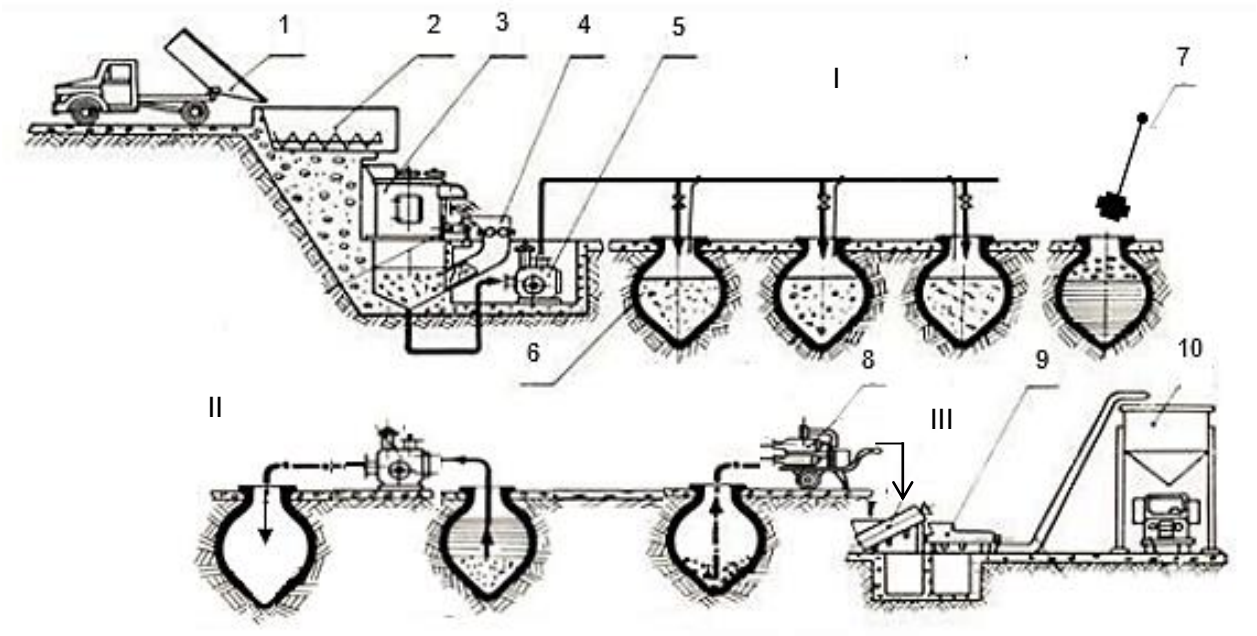
The coating is accomplished by executing circular movements from the bottom to the top, using a stick with a cloth previously immersed in the melted beeswax.

Normally, the necessary beeswax quantity for 1000-1500 Liters is 1.5 - 2 kg and the coating process can be repeated once every 5 years (Barisashvili, 2011).

The Kakhetian and Imeretian winemaking processes

There are two types of traditional winemaking methods in Georgia: Kakhetian and Imeretian, both involving the use of qvevri vessels.

Figure 13 schematically illustrates the Kakhetian winemaking flow chart.



1- Grape delivery vehicle; 2- Receiving bunker; 3- Crusher (Crusher- Destemmer, optional) machine; 4- Stems removal machine (optional); 5- Pump; 6- Qvevri vessel; 7- Cap punch down tool; 8- Pomace pump 9- Pressing machine; 10- Tank for press sections storage

I – Pre and During Fermentation operations; II- Racking of the qvevri wine; III- Final removal of chacha

Figure 13: Flow chart of the production of table wines following the Kakhetian method

Source: Baghaturia, 2010

The Kakhetian wine making method follows the next steps: delivery of the grapes to the winery (1), (2), crushing of the grapes, with or without destemming (3) and adding the juice and solid parts, by pumping (5), in the qvevri vessels (6), filling three-quarters of their total volume. The alcoholic fermentation starts either spontaneously or by adding selected yeast. As the qvevri vessels are buried underground, the fermentation temperature is maintained to around 23-25°C. During fermentation, the pomace, which rises to the surface, is manually punched down a few times a day with a special tool (7), illustrated in Figure 14. The aperture is covered with a piece of cloth, in order to avoid oxidation and contamination (Baghaturia, 2010).

The malolactic fermentation most often follows the alcoholic fermentation.

Once the fermentation is finished, each of the qvevri vessel will be completely filled with wine and hermetically covered, as a rule, with a piece of glass, sealed with wet clay against the pot's lips.

The finalization of the alcoholic fermentation occurs, usually, during the decrease of ambient temperature, which induces wine stabilization by the tartrate formation and their further elimination.

The wine is left to mature on the pomace up to 6 months, following its racking in another qvevri, tank or barrel (II). The left pomace (*chacha*) is removed using either a pump or a buckets and is further processed by pressing (9), (10) and distilling to produce pomace brandy- *chacha*.

Figure 14: Cap punch down tools, right- applied in case of white wines; left- applied in case of red wines at Bolero & Co

The Imeretian process of wine producing is less widespread than the Kakhetian one, being common in the Eastern region of the country, and it is distinguished by using only one third of the pomace during fermentation (Barisashvili, 2011). For instance, *Khareba Winery*, which produces wines both in Kakheti and Imereti region, kindly shared that, in their case, the alcoholic fermentation takes place on 100% pomace and 20-30% pomace, respectively, which, in case of the Imeretian method, leads to more delicate wines.

Cleaning

As a rule, cleaning (Figure 15) plays a crucial role in the quality of the wines. In case of qvevris, due to their special nature, a particular cleaning process must be followed, which should be mentioned.

Both lime aqueous solution of CaOH2 10-15 l water to 3-5 kg lime and a sodium water solution (2-3 %) (known as “ash-wash”) sifted wood ash is poured into water, mixed well and boiled. Proportions are 1-1.5 kg of pure sifted ash to 3-5 liters of cold or boiling water. can be used as washing agents, which are effective and do not damage the interior walls, as opposed to sodium bicarbonate NaHCO3 (soda), which can deteriorate the vessel.

In case of the winemaker opts for lime water, the general proportion used to create the washing mixture is 3-5 kg lime to 10-15 L water, which requires approximately 2-3 hours to dissolve. The solution is ready to use after its separation from the undissolved particles. In order properly wash the whole area, a special qvevri brush (made from the St.-John's wort roots) or hand brush should be used (Barisashvili, 2011).

Special attention should be paid to removing the lees and tartrates from the pores of the walls, as they can deteriorate the vessels if accumulate.

As a final cleaning step, the qvevris are rinsed with water.

After cleaning and before wine filling, it is recommended to burn Sulphur inside, in order to decontaminate the interior of the vessel. The use of sulfur can be used either just after washing or when completely dry. In the first case, the smoke reacting with the moisture will form sulfuric acid, which is very practical as deeply disinfecting the pores. However, if the sulphur is to be burnt in a dry vessel, is qvevry is left to dry, but the water has not completely evaporated, the smoke reacting with water droplets will dry and make a form a white-yellowish crystal coating on the inside walls, which can impair a bitter taste to the wine (Barisashvili, 2011).

Figure 15: Picture taken during the cleaning process of the qvevri vessel at Shumi Winery

4. Research results on Qvevri wines chemical and sensory characteristics

The Georgian wine industry finds itself in a period of growth, rediscovery and revival.

The unique winemaking traditions, namely, the use of qvevris, the collection of over 500 native grape varieties (Ketskhoveli et al., 2012) and the Kakhetian winemaking method is leading to an increasing gain in popularity among wine researchers and enthusiasts.

In addition, due to the increasing consideration regarding health and environmental sustainability, there is registered, on one side, a rising demand, originating from the consumers, for synthetic chemicals free products and, on the other side, farming and processing awareness from the grape growers and winemakers (Galati et al., 2019).

Consequently, there is a more prominent focus on adopting and implementing more sustainable production practices, which leads to the increase in popularity of organic, biodynamic and natural wines.

This statement is supported by the novel data from IWSR Drinks Market Analysis, which reports a speedy growth in organic wine in the following years. Namely, by 2023, one billion bottles of organic wine are anticipated to be consumed worldwide, which is more than twice the value of 441 million bottles registred in 2013 and up to up 34% from 729 million bottles, in 2018 (Waterworth, 2019).

Similarly, the biodynamic farming records a continuous grow. Specifically, up until 2017, 639 wine producers, covering 11,000 hectares were registered by Demeter, a certifier body of biodynamic farms and products (Castellini et al., 2017).

Due to the low intervention during the winemaking process, qvevri wines share similarities with these alternative types of wines.

Considering all the above mentioned, Georgian wines represent both a demanded product and a model, that could provide important and valuable insight regarding the potential of national grape varieties and winemaking practices.

However, despite the growing interest, there is little research investigating the national varieties, qvevri vessels or winemaking techniques. As consequence, the main objective of the Literature Review is to present the most recent results of a few scientific publications regarding both chemical composition of qvevri wines and of market analyzes of Georgian wine production, sale trends and prospects.

As previously mentioned, the traditional Kakhetian winemaking involves a prolonged maceration of the wines on the skins, both for red and white wines. According to Jackson, 2008, extraction of various compounds like phenolic, aroma or mineral compounds is generally linearly dependent on temperature and duration.

Earlier literature suggests that the extended maceration period can induce the following effects:

- Enhancement of the phenolic content of the wine, which can have both positive and negative effects. It is worth mentioning that, in case of white wines the richer phenolic extraction does not lead to the same degree of astringency as in case of red wines, which is explained by the absence of anthocyanins. As anthocyanins tend to bind with catechins and other flavonoids, the tannins solubility increases, which allows for their suspension in wine and retaining their astringent proprieties. Consequently, due to the lack of anthocyanins, the tannins precipitate during fermentation, restricting their effect on wine's sensory profile and overall evolution (Jackson, 2008);
- During the maceration period, in case of red wines, anthocyanins are extracted through a diffusive process and their proportion is reduced after a few days when the rate of anthocyanins undergoing various reactions surpasses the extraction rate (Setford et al., 2017);
- The diffusion process of the proanthocyanidins is conditional of the existing tannin concentration in the wine. The dissolution process, however, is independent of their concentration (Setford et al., 2017);
- Enhancement of the extraction of phenolic acids in white wines. Compounds of great

interest are caffeic and coumaric acids, and flavonols, such as quercetin, which are potent antioxidants (Ribéreau-Gayon et al., 2006);

- Decrease of the oxidation– reduction potential, which has a direct effect on reduction of copper and subsequent copper casse formation. However, it is important to mention that the presence of lees favors the copper fixation, which prevents the apparition of copper case (Ribéreau-Gayon et al., 2006);
- Increase in zinc concentrations (Ribéreau-Gayon et al., 2006);
- Dissolving of mineral and organic salts, mainly present in the solid parts of grapes (stalks, skins, seeds, and cell walls) (Ribéreau-Gayon et al., 2006);
- Release of polysaccharides due to the yeast autolysis (Ribéreau-Gayon et al., 2006);
- Promotion of monoterpenes uptake and of glycosidase activity and subsequent release of terpenic alcohols (linalol, geraniol, nerol, citronellol, etc.), which have significant role in the varietal aroma (Ribéreau-Gayon et al., 2006);
- Increase of amino acids, fatty acids and higher alcohols content (Jackson, 2008);
- Reduction in hydrogen sulfide production by the yeast, as an effect of increased amino acid availability (Jackson, 2008);
- Decrease of the total acidity, as an effect of increase release of potassium and formation and precipitation of tartrate salts (Jackson, 2008);
- The white wines submitted to a longer maceration period (120 days) provide a higher TPC, direct vasodilatory and antioxidant activity than conventional produced wines. In the first case, the exposure to air and subsequent brewing does not significantly affect the abovementioned proprieties (Milat et al., 2019);
- In a study researching the chemical effects of post-fermentation extended maceration (EM) (one and six months maceration period) in Pinot noir and Zinfandel wines, it was shown that the main consequences of EM were the decreased the chromatic, anthocyanin and anthocyanin-derived pigment composition of the wines. Although large polymeric pigments concentration was pronounced in EM, the total polymeric pigment content was not changed the any of the winemaking practices. Regarding the tannins, the 1 month EM did not have a strong impact on the extraction level. However, the 6 months EM wines recorded a 13-fold (Pinot noir) and a 1.6-fold increase (Zinfandel) in tannins, respectively, compared to control wines. The authors suggested that the tannins extraction during maceration could be conditional of the desorption of formerly extracted tannins during prolonged contact period (Casassa et al., 2019);
- In a research studying the evolution of chemical parameters during red wine making with

extended post-fermentation maceration (up to 90 days) it was shown that different maceration periods had distinctive outcomes regarding the polyphenol content, with maximum values being detected at 40-50 days. This period also coincided with the highest recorded antioxidant activity. The proportion of volatile compounds increased until the end of the maceration process, with no recorded off-odours and/or off-flavours (Francesca et al., 2013);

It is established that, among other factors, a high content of polyphenols, supports and increases the ageing potential of the wines. Hence, it is of great interest to study rich phenolic white wines both in relation to their tasting profile and chemical activity.

Regarding ageing and maturation, conventional ageing is based, preferentially, on either the use of neutral recipients like stainless steel tanks, concrete containers, coated with epox or wooden barrels. However, in the recent years, earthenware containers are gaining attention. Due to the microporous texture of the walls, which allow for the air exchange, similar to the wood barrel. Moreover, contrary to the wooden barrels, the qvevri vessels do not convey any foreigner compounds that would modify the wine aroma and phenolic composition, preserving the varietal aroma of the grapes.

Therefore, it is fundamental to research the evolution of wines in these earthenware vessels in order to assess their potential.

The following paragraphs will present the latest results on how the Kakhetian winemaking practices influence the antioxidant activity, the phenolic and mineral content and the overall profile of the wines. Moreover, the data is compared to wines obtained by application of the conventional technologies (in case of red wines, the must is fermented in stainless steel tanks, followed by a maturation period of maximum 30 days, in case of white wines, the juice is fermented without pomace) from previous literature.

4.1 Classical oenological characteristics

A study conducted by Díaz et al. (2013) assessed 20 qvevri wines from Europe and the obtained data was compared to earlier published results for conventional wines. The results revealed that both white and red qvevri wines measured higher pH values (3.81 for the white wines and 3.78 for the red wines) than conventional wines. The authors compared he values to various data from previous literature and placed the qvevri wines on the upper range of pH.

The high pH could reflect the prolonged skin maceration period, which was common for all analyzed wines. It is important to mention that an increased pH could negatively affect the quality of wine. Namely, it could cause instability problems regarding color, as the pH affects the anthocyanin equilibrium (as pH increases, the red form flavylium cations decrease and blue quinonic bases, colorless carbinol and pale yellow –colored chalcones proportion increase). The

high pH can also cause low efficiency of sulfur-dioxide and risk of microbial contamination and spoilage (Gardner 2017, Jackson 2008).

The wines also registered values of total acidity on the lower range compared to conventional wines, namely, mean values of 5.34 and 5.20 g/L tartaric acid for white and red wines, respectively.

The VA was under the maximum legal value, however, the values were on the upper range (0.8 g/L for white wines and 0.65 g/L for red wines). This could be explained by the long maceration period or juice/wine exposure to oxidative conditions. Another possible reason could be the metabolism of nonSaccharomyces yeast, which are dominant at the beginning of spontaneous wine fermentation (Moreno-Arribas & Polo, 2009).

Lactic acid concentrations were within regular range, according to literature. However, the malic acid recorded decreased values. The authors mention that the underground temperature where the qvevris are buried could support the Malolactic Fermentation, which would explained its decline. The wines also registered low levels of tartaric acid, which could be explained either by the initial of tartaric acid from the grapes or the precipitation as a potassium salt during aging (Butzke, 2010).

4.2 Phenolic composition

One of the main detrimental problems to white wines is oxidation spoilage, which causes faulty changes in color, aroma and sensory proprieties. As reported in literature, the main substrates for oxidation are phenolic compounds which lower the redox potential by combining with the oxygen (Jacobson, 2006). Namely, the most common fault is related to the unstable color after bottling, which is a result of o-diphenols oxidation in presence of grape polyphenol oxidase and oxygen. The formed compounds, quinones, polymerize , forming macromolecules that have a yellow-brown hue (Recamales et al., 2006).

It is well known that phenolic compounds minimize the negative effects of oxidation by scavenging free oxygen radicals (Ribéreau-Gayon et al., 2006; Jackson, 2008). Tauchen et al. (2015) conducted a study comparing the **antioxidant activity** and the phenolic composition between the wines produced in Georgia and the wines made in Central and Western Europe.

The paper showed that the wines produced in Georgia exhibited an overall higher antioxidant capacity and total phenolic content, especially for the whites. Namely, the red wines presented a greater amounts of quercetin, kaempferol and syringic acid content (7.36, 0.59, 9.00 µg/mL, respectively), with Saperavi red grape variety wine recording the highest values.

The white wines produced using the Kakhetian method presented antioxidant activity similar to some red wines, with TPC (total phenolic content) values of 1.88 g gallic acid/L wine,

while the rest of white wines fermented using the traditional method, showed values between 0.2–0.3 g gallic acid/L wine.

The authors concluded that, in case of the red wines, the differences of these parameters are correlated to the cultivars and geographical origin, while, for white wines, the winemaking method had a greater impact.

Taking into consideration the above mentioned, the results of this study suggest that the amber white wines, produced following the Kakhetian method, will be more protected against oxidation, due to the higher phenolic extraction and consequent higher antioxidant activity.

Another study (Shalashvili et al., 2011) revealed that Kaketian wines substantially exceeded the average quantity of **total phenolic compounds** compared to conventional wines. Namely, the Kakhethian white wines registered 1.33 - 2.43 g gallic acid /L of TPC while the European white wines registered only 0.21 – 0.46 g gallic acid /L. In case of the red wines, the Kakhethian red wines recorded 2.89 - 4.41 g gallic acid /L while European reds 1.63 – 2.34 g gallic acid /L.

Shalashvili et al. (2012) obtained similar results. The Kakhetian wines made of the indigenous grapes Rkatsiteli and Saperavi recorded 2.16 g gallic acid /L and 4.32g/l, respectively, of phenolic compounds.

In addition, the study, gave an insight of the quantity of some specific phenolic compounds. Namely, in Rkatsiteli white wines there were not found any significant quantities of protocatechuic acid, gallic acid, caffeic acid, o-coumaric acid or syringic acid. In case of the red Saperavi, from the hydroxybenzoic acids: protocatechuic and gallic acid counted 14.5 mg/l and 21.8 mg/l, respectively, while for hydroxycinnamic acids, there were about 7.4 mg/l of caffeic acid and traces of o-coumaric acid and syringic acid.

Díaz et al. (2013) concluded that in case of the white wines, the total phenolic content was higher (up to 10 times) than conventional whites, while for reds, the two different methods leaded to similar phenolic content, however, the anthocyanin content being greater.

Regarding the **content of catechins**, according to Shalashvili et al. (2011), the red wines prepared using the Kakhetian method had values between 798 and 1010 mg/l, while for the white, between 453 and 1097 mg/L.

In a study by Shalashvili et al. (2012) the Rkatsiteli wines recorded the following values for the catechins: (+)-catechine (32.6 mg/l), (-)-epicatechine (58.6 mg/l), (-)-gallocatechine (43.7 mg/l), and in red wine Saperavi: (+)- catechine (115.4 mg/l), (-)-epicatechine (29.5 mg/l), (-)-gallocatechine (174.4 mg/l), respectively.

The authors compared the values to regular French wines, which, for whites, had average values of 9.8 mg/l and 5.3 mg/l for the (+)- catechine and (-)-epicatechine, respectively. For the French reds, the values for (+)-catechine ranges between 22.1-130.7 mg/l, and the quantitative contents of (-)-epicatechine varies between 7.8-39.1 mg/l.

As for **resveratrol levels**, according to Tauchen et al. (2015) the Georgian red wines revealed the lowest concentrations, compared to Central and Western Europe wines, with average values of 1.56, 5.22 and 2.88 mg/L respectively.

Similar values were recorded by Shalashvili et al. (2012), white wine Rkatsiteli registred very small amounts of resveratrol, while in red wine Saperavi its amount equaled 1.47 mg/l.

However, it is important to note that although Georgian varieties register low resveratrol concentrations compared to the international grape varieties wines, the winemaking method has a strong effect on the extraction of this type of phenols. Namely, Surguladze and Bezhuashvili (2017) compared the effect of wine technology on the concentration of resveratrol in Saperavi wines. The experiment showed that the Kakhetian wines recorded a higher content of cis-resveratrol and a big quantitative difference of trans-resveratrol (2.38 mg/l and 0.24 mg/l) compared to the traditional fermented wines.

These results are also supported by a similar study (Chkhikvishvili et al. 2008), which obtained a greater content of resveratrol (5.82 mg/l) in Kakhetian style Saperavi than the sample prepared by European method (0.69–1.17 mg/l).

These findings are in line with previous acknowledged information. Namely, that the proportion of stilbenes in wines relies on various factors, like climate, grape variety, fungal disease, UV light, heavy metal ions and winemaking practices (Moreno-Arribas & Polo, 2009).

Taken together, the findings regarding phenolic content suggest that, in case of white wines, the qvevri wines present a greater total phenolic content than conventional white wines, reflecting the extended contact skin period. The intense extraction of these compounds leads to a stronger perception of astringency and aroma extraction.

In case of white wines, an extended maceration on skins can deliver sufficient polyphenols to protect the wine against oxidation. The added benefit is the reduction of the needed sulphur dioxide addition, that acts as an antioxidant and which amount is limited by legislation (the maximum quantity allowed by European legislation is a total concentration of 150 mg/L in red wines and 200 mg/L in white and rosé wines containing a maximum of 5 g/L of reducing sugars) (EU Regulation No. 606/2009).

In case of red qvevri wines, the phenolic content and antioxidant status is similar to traditional red wines, with the mention that the anthocyanin levels were higher.

4.3 Mineral composition

Regarding **mineral content**, the study conducted by Díaz et al. (2013) revealed that in spite of being produced in clay pots, the mineral levels of qvevri wines, except for phosphorus, which recorded higher values and copper, which recorded lower values, were within the regular limits, compared to prior record data from literature.

These results could be explained by the lime treatement followed by the beeswax coating, which averts an excessive mineral leaching into the wines. The higher level of phosphorus was expected, as the longer maturation period would cause its extraction from the grapes skins. The low levels of copper, on the other hand, could be explained by its adsorption by the lees (Ribéreau-Gayon et al., 2006).

4.4 Sensory characteristics

The general **tasting profile** of the red wines can be described as mineral and fresh, as they maintain their primary aromas. Qvevri red wines have an intense purple colour, with the tannin structure similar to conventional wines. The white wines, on the other side, have a particular profile. The intense amber color and the tannic structure reflects the long maceration period (Díaz et al. 2013, Baiano et al., 2014). Their bouquet are slightly reminiscent of almonds, walnuts, chamomile, straw and dried apple (Feiring, 2016).

4.5 Overview of the effect of in-amphorae aging on oenological parameters

In the last decades, the globalization and the intense market strategies towards consumer recognition facilitated the widespread of certain varieties among wine producing countries, leading to the rise of so-called *international varieties*. However, currently, more wine producers aim for product differentiation and target the enhancement of particularities and typicality of their wines.

Therefore, due to their nature, clay types of amphorae could be a promising alternative to the traditional ageing containers, as they provide the positive effects of micro-oxygenation, delivered by wooden barrels, without the extraction hydrolysable tannins and aromas (Ribéreau-Gayon et al., 2006) with the subsequent alterations in the wine's composition.

Despite the recent interest on the effect of fermenting and/or ageing the wine in qvevri vessels on the physico-chemical proprieties of the wines, the topic has been overlooked by the scientific community. However, as qvevris share similarities to various types of amphorae, the following paragraphs will investigate the existing studies in attempt to present a general overview of these type of vessels and their potential.

A research conducted by Baiano et al., 2014 analyzed the effects of wine ageing in different types of containers: raw, glazed, and engobe amphorae, and in stainless steel tanks. The

three types of clay amphorae were treated in different ways. The raw amphorae were fired at 1100 °C; the glazed type were fired once at 1100 °C and then at 970 °C, the walls were coated internally with vitreous particles suspended in water that turn to glass when fired; the engobe type was fired first at 970 °C and then at 1100 °C. The white wines were aged on lees during a period of 12 months.

The results revealed that the oenological proprieties of wines were influenced both by ageing period and the type of container. Moreover, in some cases, the ageing time had an accentuating effect on the influence of container.

The organic acids (lactic, acetic, citric, and succinic, the hydroxycinnamoyl tartaric acids) were affected solely by the ageing period and not the type of container, while the antioxidant composition and capacity were affected both by ageing and type of container.

Namely, in case of the engobe amphorae and stainless steel tanks, it was noticed a greater retention of phenolic compounds, especially of flavans reactive with vanillin. In case of the raw and glazed amphora, the wines, the proportion of flavans reactive with vanillin considerably decreased. However, the wines maintained their antioxidant capacity after 12 months.

Although it would be expected that the amphorae would provide with a lower level of antioxidant preservation than stainless steel tanks, over the one year ageing, the antioxidant capacity decreased by 28%, 31%, 39%, and 43% in raw, glazed, engobe amphorae, and stainless steel tanks, respectively.

The authors suggested the results could be explained by the theory that part of the oxygen that penetrated through the amphorae walls was utilized for the oxidation of ethanol to acetaldehyde catalyzed by transition metals.

The reduction of the antioxidant capacity was consistent with the recorded reduction of the phenolic contents.

Overall, comparing the final set of results, it was observed that the most prominently distinct results were recorded between the wines aged in raw amphorae and in stainless steel tanks, while wines aged in glazed and engobe amphorae registered intermediate characteristics.

Another similar study conducted by Baiano et al., 2015 researched the evolution of the in-amphorae aging on oenological parameters, phenolic profile and volatile composition of Minutolo white wine. The wine was produced by cryomaceration combined with reductive vinification and stored, after racking from the lees, in three types of containers: raw, glazed, and engobe earthenware amphorae and glass containers and aged for a period of 12 months.

The results indicated that the wines aged in glass containers revealed the highest concentration of alcohol content, VA, dissolved oxygen, concentrations of aromatics, alcohols,

and esters and lowest concentrations of enols and terpenes. They also showed the most pronounced decrease of flavonoids.

Regarding the wines aged in amphorae, they recorded a considerable reduction in alcohol content of about 1%vol. The authors explain the effect as a consequence of either the evaporation through the porous walls of the vessels or the acetaldehyde oxidation.

The wines aged in amphorae also registered a decrease of TA titratable acidity, while in case of the wines stored in glass containers, the values didn't change. The authors suggest as a possible explanation that the clay reacts with acids leading to a cation exchange, with the removal of small amounts of SiO2, Al2O3, Fe2O3, and the formation of H-clays.

The results also showed the following free/total SO2 ratios: in engobe (6%), glazed (7%), raw (20%), glass container (11%). In case of engobe and glazed amphorae, the values of the highest proportion of bound SO2 correlate with their lowest levels of dissolved oxygen.

Overall, the wines aged in raw amphorae, they displayed a great reduction of flavonoids and flavans reactive with vanillin with the total phenolic content decreased by 14% in glazed amphorae and glass containers, 11% and 9% in raw and engobe amphorae respectively.

Although, it was expected an opposite outcome, the lowest values of antioxidant activity were recorded in the wines stored in glass containers and glazed amphorae. The authors suggest that the part of the oxygen that entered through the amphorae walls was consumed for the oxidation of ethanol to acetaldehyde catalyzed by transition metals and, therefore, it did not involve the phenolic oxidation.

In case of the aromatic volatile compounds, the compounds decreased in engobe amphorae (− 39%), remained unchaged in raw amphorae, and increased in glass containers (+ 249%) and glazed amphorae (+ 15%). The wines stored in glazed amphorae had a poor volatile profile, with the lowest concentrations of volatile acids, alcohols, acetic esters, and ethyl esters.

It can be concluded that despite the impermeability of glass containers, the most positive results of oenological parameters, antioxidant content, and volatile profiles were showed by the wines aged in glazed and engobe amphorae.

Finally, despite the interest regarding Georgian wine and specifically the use and impact of qvevris on the final product, there are few studies investigating the subject. The existing researches highlight the interesting particularities of prolonged skin maceration and ageing in amphorae, especially in case of the white wines, and give an insight on the possible outcomes of the wine produced following the Kakhetian method.

However, at the moment, it is unclear how big of a factor is the specifically usage of qvevris on the particularities of the wine, or if the different winemaking method, namely, the prolonged maceration time and the micro-oxidation that occurs in the qvevris play the principal role in the wine characteristics.

The main question remains whereas all the cumulative aspects of qvevri usage deliver to the wines special features, which cannot be reproduced otherwise. Hopefully, further tests will answer to this question.

5. Comparison between Qvevri and Talha wines

Throughout the history, the use of pottery vessels for winemaking evolved throughout Phoenician, Assyrian, Egyptian, Greek, and Roman territories (McGovern et al., 2017). These ancient pots ceased to be used, as an effect of winemaking modernization. However, the practice of using amphorae still continued in a few regions, mainly in Georgia, Portugal (Alentejo) and Italy (Friuli, Campania, Sicily). Moreover, in other locations like France (Corsica, southern Rhone Valley, Beaujolais), Croatia (Istria), U.S. (Napa Valley), Slovenia (‘Goriška Brda) and Austria (Thermenregion) the use of earthenware pots as fermentation or ageing vessels is also common. (Baiano et al., 2014).

Despite the 6000 years period of time and over 5000 km territorial separation, both qvevri and talha (Alentejo, Portugal) vessels evolved in a parallel manner. Therefore, as it would be interesting to present and compare these two types of clay pots, the next chapter will focus on the particularities and differences of the amphorae use in Georgia and Portugal.

The similar size, shape of the vessels and the winemaking techniques indicate that the continuous observation and mastering from both cultures concluded in an ideal model that incorporates practicality and spirituality.

The most prominent distinction between the two is that the qvevri vessels are completely buried underground, while talhas stand on the surface (Figure 19 & Figure 20). Both approaches present advantages and disadvantages. In case of qvevris, as mentioned in a previous chapter, the main benefit of being buried is the maintaining of constant temperature and reduced risk of explosion during fermentation and of breakage during cleaning. The talhas, on the other hand, can be more easily moved and manipulated

Figure 16: Picture of the qvevri cellar (marani) at Shumi Winery

Figure 20: Picture of talha vessels, Alentejo

Source: Wines of Alentejo, 2016

Another major difference is that the impermeabilization and antiseptic conditions of the qvevris are ensured by coating the interior with beeswax, applied directly after firing. The beeswax fills a grand proportion of the pores, reducing the oxidation risk. Talhas are covered inside by pine pitch (pês), which is also waterproof and possesses antimicrobial properties (Martin, 2018)

Both qvevri and talha wines follow a similar winemaking process. The grapes are mechanically crushed and, optionally, destemmed and the berries are further placed in the vessels. During the alcoholic fermentation, the floating cap is manually broken down and stirred using an wooden paddle.

In the case of qvevri, the lower soil temperature, and the overall reduced temperature fluctuation, ensure suitable conditions for the successful ongoing alcoholic fermentation. However, an underground network of pipes can be added, in order to circulate cold water, if necessary.

Portuguese winemakers, on the other hand, reduce the temperature either by pouring cold water on the surface, several times a day, or by wrapping wet pieces of fabric around the vessel. These methods allows for a drop in temperature of 3-5 °C. The raised, rope-like decoration around its neck helps controlling its in-built heat-exchange system. Water, run from above, is evenly distributed across the talha's belly. Aldo, the purposefully coarse surface, helps absorbtion (Prytkov, n.d.).

After fermentation, the qvevri wine is kept on the pomace (chacha), usually, from 2-6 months for red and up to 6 months for white wines. The top is hermetically covered, using clay and, usually by glass and sand on top. Customarily, the wine is racked at the end of March, by

pumping the wine from the top. The pomace is removed using buckets the same wooden paddle used for the breaking the skin cap.

In case of the talhas, the upper mouth of the amphora is covered with clean cloth or wooden top. The wines are kept in contact with the pomace until the 11th of November, Feira de São Martinho, when is declared ready to be drunk. The wines are racked from the clay vessels passing through the solid parts of the grapes that has fallen to the bottom of the vessel and act as a filter. They can be bottled or preserved in the same vessels, but as little or no sulphur (Martins et al., 2018). The first 15-20 Liters, which are cloudy, are seaparated and reintroduced back in the top of the pot. The wine is racked of the vessel through a hole situated about 30 centimeters above the bottom, which is normally closed with a cork called a «batoque». The solid parts, provide a natural filtering medium. Consequently, the wine, passing through this layer becomes clear, ready to be bottled (Prytkov, n.d.).

It should also be noted that it is common in Alentejo to produce petroleiro (a wine made by mixing white and red grapes) (Martins et al., 2018).

Both qvevri and talha wines can be further stored in tanks, barrels or the clay vessels.

A study by (Cabrita et al., 2018) aimed to investigate the oenological parameters and the mineral content of 47 talha wines samples from Alentejo, Portugal.

Table 1 and 2 present a concise comparison of oenological parameters and mineral content between qvevri, talha and conventional wines.

Analyzing Table 1, it can be observed similar high pH values for both qvevri and talha. However, no conclusion can be withdrawn as according to Cabrita et al., 2018, the pH values for talha wines are in accordance with values of the conventional wines from Alentejo (the region where the samples were taken from).

Both types of wines also record values of the VA on the upper range, although within the legal European limit of under 1.2 g/L.

Table 1: Comparison of the oenological values between qvevri, talha and conventional wines (TA – total acidity; VA – volatile acidity)

Parameter	Mean value Qvevri wine	Mean value Talha wine	Reported values	References
	Díaz et al. 2013	**Cabrita et al., 2018**	**Conventional wines**	
pH	white – 3.81 red – 3.78	white – 3.64 red – 3.78	white – 3.0–3.4 red – 3.4–3.6	Ribéreau-Gayon et al. 2006, Jackson 2008
TA (g/L H_2T)	white – 5.34 red – 5.20	white – 5.51 red – 5.71	white – 5.0–10.1 red – 5.4–7.9	Ribéreau-Gayon et al. 2006, Vilanova et al. 2009
VA (g/L acetic acid)	white – 0.80 red – 0.65	white – 0.52 red – 0.70	white – 0.1–0.5 red – 0.3–1.0	Jackson 2008, Vilanova et al. 2009
Tartaric acid (g/L)	white – 1.33 red – 1.13	nd	white – 2.3–3.5 red – 3.0–4.8	Ribéreau-Gayon et al. 2006, Vilanova et al. 2009
Malic acid (g/L)	white – 0.21 red –0.12	nd	white – 0.1–5.4 red –0.3–2.6	Ribéreau-Gayon et al. 2006, Vilanova et al. 2009
Lactic acid (g/L)	white – 1.74 red –1.69	nd	white – 0.06–3.9 red –0.06–3.9	Ribéreau-Gayon et al. 2006, Peres et al. 2009

Table 2: Comparison of the mineral content between qvevri, talha and conventional wine

Elements	Díaz et al. 2013		Cabrita et al., 2018		Reported values		References
	Qvevri wines		Talha wines		Conventional wines		
	White	Red	White	Red	White	Red	
K (mg/L)	197–536.5	351.8–518.4	678-1485	617 - 1823	115.3–612.2	650.7–1732.9	Ribéreau-Gayon et al. 2006 Laurie et al. 2010
Ca (mg/L)	49.5–97.2	55.2–77.2	42.71-105.78	29.13-163.18	44.7–108.8	53.1–160.9	Ough et al. 1982, Ough and Amerine 1988, Álvarez et al. 2007
Zn (mg/L)	0.4–0.9	0.53–0.94	0.44-1.45	0.47-7.03	0.08–1.5	0.2–1.6	Ough et al. 1982, Ough and Amerine 1988, Álvarez et al. 2007
P (mg/L)	107.7205.0	196.3–255.7	165.71-320.41	189.14-347.51	54.6–88.0	54.6–88.0	Álvarez et al. 2007
Mg (mg/L)	62.6–107.9	85.7–127.0	88.52-132.38	100-211	56.2–131.0	94.3–196.0	Ough et al. 1982, Ough and Amerine 1988, Álvarez et al. 2007
Fe (mg/L)	0.07–1.6	0.4–4.3	1.18-12.2	1.92-6.01	0.04–6.8	0.9–9.3	Ough et al. 1982 Banović et al. 2009, Provenzano et al. 2010
Cu (mg/L)	0.03–0.5	0.02–0.04	0.006-0.37	0.009-0.092	0.03–0.4	0.2–1.2	Banović et al. 2009, Provenzano et al. 2010

The minerals concentrations of both the talha and qvevri wines were in accordance with those found in literature.

Overall, the clay material of the pots did not affect the mineral content of the wines. The pine pitch (in some cases with epoxy resins) used to coat the inside part of the talhas is effective as impermeable material. In a similar study, (Díaz et al. 2013) concluded that the lack of the anticipated exogenous minerals, which would be leached from the qvevri to the wine, was due to the use of beeswax.

6. Trends and Prospects on Georgian wine production

The Georgian wine industry reports a momentum regarding governmental and private investment, production and, lastly, demand and export.

6.1. Production

In 2019, 245 wine companies were recorded to be involved in the processing of grapes, and 1088 Georgian wineries have been registered to be involved in wine commercialization (LEPL National Wine Agency, Report III Quarter, 2019). Over the past years, the development of market, substantial profit margins and availability of state funding through grants and loans, facilitated and increased attractiveness among small producers, which is evident through the 2.3x increase of wine producers from 2010 until 2019 (Figure 16) (Kordzaia et al., 2020).

According to Galt & Taggar's research on Georgian Wine Industry, the wine production almost doubled over the 2013-2018 period, counting about 117mn liters of wine in 2018 (Bochorishvili et al., 2019).

The government plays a key role in supporting the development of the Georgian wine industry, by offering advantageous grants and subsidized loans. This valuable assistance increased the number of small-scale wineries and the overall production quality (Bochorishvili et al., 2019).

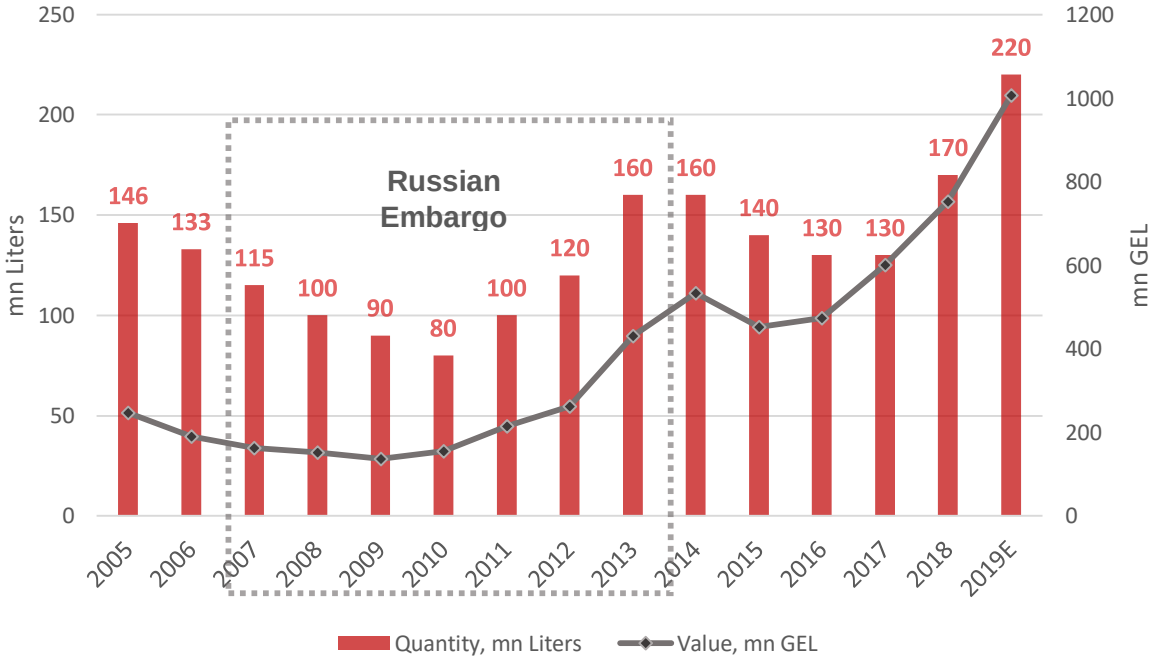


Figure 17: Production of wine in Georgia by Volume (million Liters) and Value (million GEL), 2005-2019E

Source: (Kordzaia et al., 2020)

6.2 Export

The main factor leading to this continuous production increase is the higher demand in export markets

According the Georgian National Wine Agency, the wine exports ranked the 4th place from the total exporting products and represented 9.4% of the country's total agricultural products in 2018 (LEPL National Wine Agency, Report III Quarter, 2019).

The same source revealed that in the first 9 months of 2019, 65.2 million bottles (0.75 liters) of wine have been exported to 53 countries around the world, which is 10% more bottles than during the same period in 2018. (LEPL National Wine Agency, Report III Quarter, 2019). According to TBC Capital, a subsidiary of TBC Bank researching the Georgian market, revealed that Georgia's wine export of 2019 surpassed the 2018 value, growing 13.2% YoY (Year-over-year), achieving an export value of 223mln USD dollars (Business Media Georgia, 2020). The first ten of the exporting countries are: Russia (63%), Ukraine (10%), China (8%), Poland (5%), Kazakhstan (4%), Belarus, Latvia, USA, Lithuania and Estonia.

Until 2006, Russia represented a key export country, accounting 78% of wine exports. However, the embargo set on Georgian wines, mineral water and agricultural products, drastically affected the wine industry, causing a decline of 50% in production and two thirds of exports. Consequently, Georgian producers reached for new markets, as CIS countries, EU and Middle East. Moreover, the free trade agreements with EU and China offered opportunities for diversification and export growth (Bochorishvili et al., 2019). Consequently, the reorientation to these new attractive markets, yielded in a production and export rise. Namely, the export to US increased to 60%, UK - 40%, Poland - 18% and China - 11%, compared to 2018. In 2008, 39 countries imported Georgian wine, while in 2019, the list of countries counted a total of 53 states (Figure 17) (LEPL National Wine Agency, Report III Quarter, 2019).

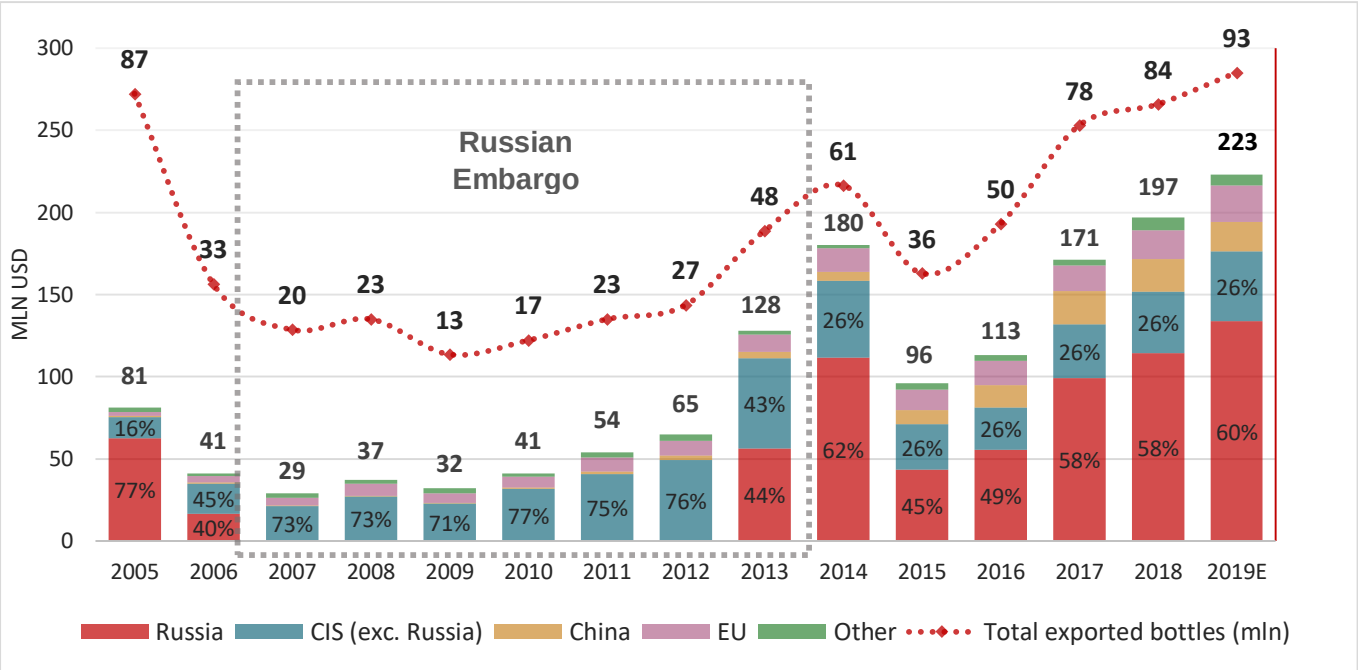


Figure 18: Georgia wine export by Volume (MLN bottles) and Value (MLN USD), 2005-2019

Source: (Kordzaia et al., 2020)

The preferred Georgian wines among exporting markets constitute the dry and semi-sweet red wines. Wines made of completely or partially from Speravi grapes share 73% of the total exports. The Georgian PDO wines show a promising potential for high-end market. (Kordzaia et al., 2020)

Regarding the average export price, Georgia stands on the same levels as Portugal, at 3.18 USD dollars/Liter, and higher than countries like Argentina, Australia or Chile (3.05, 2.52, 2.35 USD/Liter, respectively) (Kordzaia et al., 2020). This could be explained by the implementation of mass production and technology advancement in those countries. The high exporting price decreases Georgia's competitiveness level, which puts pressure on either modernization regarding production or product differentiation.

6.3 Current position on the international market

As mentioned above, Georgian wines recorded a dramatic growth in USA, following an increase of a three-year average growth surge of 54% YoY, placing USA the 10th export market. Julie Peterson, Managing Partner of Marq Wine Group explains the success of Georgian wines in USA: "This growth can be attributed to a blend of three market variables: wine professionals have discovered Georgia's indigenous varietals, which reflect a deep sense of place. There is growing interest in low-intervention wines, and because Georgians have continually produced wines using

natural, ancient methods for 8,000 years, they stand at the epicenter of this practice. Finally, the 'amber' or skin contact wine category, which emerged a few years ago, continues to build exponentially." (PR Newswire, 2019).

In a recent interview for BBC news outlet, Irakli Cholobargia, Marketing and Business Consultant of the Georgian National Wine Agency, stated for BBC that there is an increasing focus on Westerned Europe and North America and that the main strategy is to establish in Western and Asian countries and to diversify the export market. This consultant also highlights that as the total production capacity is limited to 300 million bottles a year, the main distinguishing points are the uniqueness of the grape varieties, qvevris and history.

In the same article, Lisa Granik, a New York-based specialist on Georgian wiens lists the main complications American consumers encounter when reaching for Georgian wines. She notes that customers experience difficulties understanding the unusual flavour profile of the wines. Ms Granik also adds that another struggle represents the Georgian names, which can be hard to pronounce and that there is an overall lack of awareness about the country among Americans.

Another possible problem represents consistency. As many Georgian winemakers choose not to add sulphur dioxide to the wine, which acts as preservative, the wines can be subject to dramatic changes under traveling conditions.

However, this specialist concludes that one of the advantages of lack of information on Georgian wines is its intricate novelty: "There are a lot of millennials who don't want a Bordeaux. They are looking for something that is weird and wild. And they like this notion of natural, anti-corporate wine that's old and ancient, and they are open to this." (Golysheva, 2019)

Another article analyzing the Georgia’s future evolution on the wine market supports the above statements. According to the author, the 520 indigenous varieties represents a rich set of opportunities to resurrect the country’s diverse viticultural heritage, which could be favorable to their product differentiation.

Just as Lisa Granik, Tara Hammond, a partner at the importer Black Lamb Wine in Oakland, California also stresses the challenge of including Georgian wines in restaurants and shops due to the lack of awareness, especially as there is not recognizable regions as the classic European appellations. (Granik, 2019)

According to a research on Georgia’s wine sector, by the Bank of Georgia, the proportion of off-trade wine is lower in EU than in Russia and Ukraine. This data suggests that a bigger proportion of wine is acquired by supermarkets rather than hotel, restaurant and catering establishments. In comparison, 50% of Turkish wine is purchased by the HoReCa sector (Gazadze & Nakashidze, 2014).

Figure 18, proposed by a research project on Georgia's Wine Sector, by Gazadze & Nakashidze (2014), illustrates the main strengths, weaknesses, opportunities, and threats related to business competition of the Georgian wine sector.

Regarding qvevri wines, although, they account for only about 10% of total wine production (Golysheva, 2019), they hold a special place in the cultural identity of Georgia. Moreover, due to the rise in popularity of Georgian wines and of the overall tendency towards natural wines, qvevri wines are gaining special spotlight, which makes it essential to further study and collect information regarding their particularities.

Figure 19: SWOT analysis of the Georgian wine industry

Source: Gazadze & Nakashidze (2014)

7. Conclusion

Archaeological excavations indicate that Georgia stands at the origin of advanced viniculture, experiencing about 8,000 vintages and collecting 525 indigenous grape varieties. However, due to its tumultuous history, the country's wine industry has passed through numerous challenges that leaded to high fragmentation and subsequent stagnant evolution. Nevertheless, the Georgian wine industry should not be seen as a case of delay in modernization, but rather a deliberate preservation of the wine traditions. This reflects the importance and the role of winemaking and viticulture in the daily life of Georgian people.

The internship carried in Georgia offered me a novel professional insight on both the national wines and the traditional qvevri vessels. I was able to observe the benefits and challenges of conducting fermentation and/or ageing in such containers.

The qvevri vessels represent an iconic symbol of the Georgian winemaking. Firstly, due to their nature, they offer a promising alternative to the traditional stainless steel tanks and oak barrels, providing the benefits of light oxidation similarly occurring in the last, without changing the primal aroma and structural profile of the wines. Secondly, as the qvevris are buried underground, the wines benefit from constant temperature and pressure, which considerably reduces the energy consumption and risks of explosion during alcoholic fermentation. Thirdly, due to the minimal intervention during the winemaking process, qvevri wines share similarities with organic, biodynamic and "natural" wines and could represent a model for the "natural" type of winemaking.

The extensive ageing period of white wines on skins, common to the traditional Georgian wines leads to powerful and structured, so called *amber wines*. The intense aroma and tannic profile of these wines might be overwhelming and foreigner to most of consumers. However, this issue can be overcame by rising awareness and offering background explanation, which are essential in educating the unexperienced consumers. Personally, I do not see the strong character of the amber wines as a selling obstacle, but rather as an asset for product differentiation. The resurgence of the Georgian wines on the international market coincides with the emerging of a new generation of wine consumers, which tends to be more experimental and focused on the emotional, innovative and educational values of the products.

Regarding the country's position on the wine market, Georgia is crossing a period of industrial revitalization and integration on the international market, positioning itself as a producer of qualitative and distinctive wines. The strong governmental support aims to reduce the negative effects of the high fragmented industry, to provide tools for modernization and to rise brand awareness of the national wines.

The data analyzing the Georgian wine sector on the market implies that there is an increasing demand for Georgian wine and that wine trade intensifies, in particular, in USA, China and EU countries. Georgia reveals continuous efforts to obtain a solid place on the international wine market. If there will be a continuous investment in brand recognition and distribution networks, it could generate an increase in awareness and sales.

However, although the grave and unfortunate situation of the COVID-19 had a limiting impact on the development of my internship, I strived to collect as much information as possible from both publications and distance discussions with local winemakers. Moreover, not being able to fully participate in the cellar work, has given me incentive to return during the harvest time, so I could gain the full experience. I am fascinated by the work involved in the qvevri winemaking and can only aspire to be part and witness the whole process of traditional Georgian winemaking.

I am most grateful for such an opportunity and can declare myself as an enthusiastic supporter of the Georgian wines and country.

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Annexes

Annex 1: Specifications of the Qvevri wine production at three Georgian wineries

Winery	Region	Production (L)		Nr of Qvevris	Qvevri size (L)	Grape Varieties used for Qvevri wines		Post – fermentation maceration period	Spontaneous Fermentation	Filtration
		Total (mn)	Qvevri			White	Red			
Bolero & Co	Kakheti	18.7	20,000	245	645 2000 3500	Rkatsiteli Kisi Khikhvi Mtsvane	Saperavi Aladasturi Tavkveri Cabernet Sauvignon	Red: 3 months White: 6 months	☒	☒
Shumi	Kakheti	1.1	37,500	21	2000	Kisi, Khikhvi KrakhunaMtsvane Rkatsiteli * rarely use stems	Saperavi Aladasturi	Red: 1-2 months White: 6 months	☒	☑
Khareba	Kakheti *the fermentation takes place with 100% pommace	6	70,000	120	950-2000	Rkatsiteli Mtsvane Kisi Khikhvi	Saperavi	Red & White: 4-6 months	☑	☑
	Imereti *the fermentation takes place with 20-30% pommace					Tsitska Tsolikouri Krakhuna	Otskhanuri Sapere Aladasturi Ojaleshi			