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“Evaluation of the enological potential of Merlot and Cabernet Sauvignon wines for the production of Premium red wines in the Padua Hills”

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Table of contents

Abstract 5
1.Introduction 7
1.1 The concept of quality for Premium wines 7
1.2 Merlot and Cabernet Sauvignon wines……………………………………………………..8
1.2.1 The vines: their history and origins..8
1.2.2 The geographic distribution of the two vines…………………………………………………9
1.2.3 Morphological, phenological features and cultivation aptitudes of Merlot and Cabernet Sauvignon…………………………………………………………………………………9
1.3 The traditional red wine-making process of quality wines……………………………………..12
1.4 The pedoclimatic and viticulture characteristics of "Colli Euganei" area…..………………………16
1.5 Sensory aspects of wines…………………………………………………………………………20
1.5.1 The sensory characteristics…..……………………………………………………………...20
1.5.2 The factors affecting the sensory evaluations…...………………………………………..21
1.5.3 The descriptive method………………………………………………………………….. 23
1.5.4. The sensory features of Merlot and Cabernet Sauvignon wines…………………………………24
2. Aim 27
3. Materials and Methods 29
3.1 Vineyards locations and the suitable cultivation systems for the two varieties……………………….29
3.2 Degree of ripeness of the grapes, the harvest and the pre-fermentation operations…………………...33
3.3 Winemaking protocol………………………………………………………………………………..35
3.4 The sensory analyses…………………………………………………………………………...36
3.4.1 The first training session…………………………………………………………………36
3.4.2 The selection of descriptors……………………………………………………………38
3.4.3 The sensory evaluation of the eleven Merlot and Cabernet Sauvignon wines……………………38
3.5 The statistical analysis……………………………………………………………………………..41
4. Results 43
4.1 Wine's analytical composition…………………………………………………………………43
4.2 Sensory analysis procedures……………………………………………………………………...44
4.3 The statistical results with the analysis of variance……………………………………………….45
5. Discussion 57
5.1 Colour, astringency, persistency and sapidity…………………………………………………….57

5.2 Aromas……………………………………………………………………………………………60
6. Conclusion...64
References...67

Abstract

The concept of quality for Premium red wines is related to the agronomical and enological improvement and to the pedoclimatic features typical of a territory. Merlot and Cabernet Sauvignon wines have some important sensory characteristics deriving from the morphological and phenological features of the vines, the territory and the cultivation and vinification techniques. This work was part of the activities of a large project focused on Super/Ultra-Premium red wines curated by CIRVE and the University of Padua, in collaboration with Coldiretti and the Consorzio Volontario per la Tutela dei Vini Colli Euganei, to create a proposal of "Protocol of Designation" of Merlot and Cabernet Sauvignon wines from the different areas of the "Colli Euganei". The project was based on eleven Merlot and Cabernet Sauvignon wines from eleven different producers located in Padua Hills and the aim of the work was to characterized these wines from chemical and sensory point of view to highlight the main variables that influence the sensory profile of the wines. The results showed higher variability for some sensory descriptors in both wines, potentially related to different characteristics of the *terroir*. This has highlighted a great interest in the production of Premium red wines starting from Merlot and Cabernet Sauvignon wines from the "Colli Euganei" area.

Introduction

1.1 The concept of quality for Premium wines

The definition of quality, according to the UNI EN ISO 9001:2015 (a quality management system of the International Organization for Standardization) is the totality of characteristics of a product or service that affects its ability to meet stated or implied needs through appropriate regulation and standardization processes to meet customers’ requirements.

The quality of wine is a concept difficult to define, it encompasses a range of objective, subjective and contextual dimensions (Beccaria & Pretto, 2021), clearly correlated to agronomical and oenological improvements (Delmastro, 2005). It includes properties connected to the organoleptic sphere like appearance, taste, freshness, sensitivity, that can be detected during the tasting to identify the intensity and the aromatic complexity of the wine bouquet (Verdú Jover et al., 2004). These quality properties are depending by different things: the grape variety, the characteristics of the place (the region or the country of origin), the optimal management of the production methods applied in the field and in the winery. All together they create a qualitative improvement to get a Premium wine, a high-quality product characterized from higher prices than the other basic wines.

Within the notion of “place”, understood not only as its physical location on the map but also its social and cultural character that influence the wine and the consumer experience (Warman & Lewis, 2019), there are two important concepts of French origin that can determine the value of a Premium wine: *terroir* and *provenance*. *Terroir* refers to a distinctiveness of wine imparted by the physical environment of the place (Warman & Lewis, 2019); is the combination of the natural factors such as soil type, climate, altitude, topography, with the human factors which are the varietal selection of the vine, the cultivation of the grapes and their high quality selection during the harvest, the process of specific vinification, the vintage, which in the end are expressed in a marked sensorial quality characterized by a complex and refined taste; is the expression of a place through the sensory qualities of a wine. Is in function of these quality results that the final consumer willing to pay an higher price for the product (Warman & Lewis, 2019).The term *Provenance* relates to the authentication of the wine, indicating where and when it is produced, how and by whom. Specifically, it includes the vineyards and cellar where it is produced, the specific parcel of land where the grapes were grown, the vintage or year the grapes were harvested, and any other important information about the production process (Warman & Lewis, 2019). This term is more linked to historical finds and has the role of communicating and confirming the authenticity of the wine along the value chain to the final consumer.

Understanding how place interacts whit the wine industry value chain is one of the most important things in a consumer's experience of Premium wines.

1.2 Merlot and Cabernet Sauvignon wines

1.2.1 The vines: their history and origins

The most commercially important grape vine varieties used for the wine production are members of the genus *Vitis* and the specie *vinifera*, and belong to the order *Rhamnales* and to the family *Vitaceae*. Within the *Vitis vinifera* L. 1753 species there are different varieties in which we find Merlot and Cabernet Sauvignon, the two of our interest for this study.

Merlot is a quality black grape variety recognized back in 1784 in the regions of Saint-Émilion and Pomerol (Robinson J., 2012), two important wine districts of Bordeaux, a wine region in France renowned throughout the world.

Currently, Merlot is also very popular in other regions and countries and competes with its more austere and aristocratic companion Cabernet Sauvignon, a renowned variety of black wine grape (Robinson J., 2014) which also comes from the Bordeaux area, in particular from the two districts of Médoc and Graves. It, also, has been exported to other French wine regions and much of the Old and New World, where it is blended with traditional indigenous grape varieties and in particular its classic Bordeaux complement: Merlot, but it is more often used to make monovarietal wines (Robinson J., 2014).

In 1999, DNA profiling technique revealed a parent-offspring relationship between Merlot and Cabernet Franc, one of the oldest grape varieties in the Bordeaux region, but the other parent remained unknown until 2009, when Jean-Michel Boursiquot found out. It is Magdeleine Noire des Charentes, an unknown cultivar sampled for the first time in northern Brittany (Robinson J., 2012). As for Cabernet Sauvignon, its parentage was discovered through DNA profiling in 1997 by Carole Meredith and John Bowers at the University of California; it turned out to be a descendant of Cabernet Franc and Sauvignon Blanc (a Bordeaux white wine grape). It is thought that this crossing occurred spontaneously in one of the many vineyards planted in the past characterized by different vines (Robinson J., 2014).

Therefore, Merlot and Cabernet Sauvignon appear to be half-brothers, as they are both descendants of Cabernet Franc. This explains a lot about their similarities which we will see later.

1.2.2 The geographic distribution of the two vines

Merlot is one of the most cultivated wine grapes in the world. This variety in France is the most planted, with a total surface in 2009 of 115746 hectares (Robinson J., 2012); even if the distribution in the country is quite homogenous, the greatest concentration is in the Bordeaux district of Aquitaine. In Bordeaux, Merlot was considered a wine of lower quality compared to Cabernet Sauvignon, until the mid-nineteenth century, when it became much more popular thanks to its resistance to powdery mildew that is still nowadays one of the most important fungal diseases of grape vine. Furthermore, the ability of Merlot to flourish even in cold years contributes to its spread, till today where it has surpassed Cabernet Sauvignon.

Italy recorded in 2010 a surface area of Merlot of 23141 hectares of Merlot (Vivai Rauscedo, 2023). The variety is distributed in fourteen of the twenty Italian regions, however, is in the north-east of the country where the highest concentration of it could be found. Friuli, Veneto and Trentino-Alto Adige regions have proven that Merlot adapts perfectly till the point to supply products that are competitive with the native ones (Cosmo I.,1964).

Cabernet Sauvignon is the dominant grape in the blends responsible for all the most famous wines made in Mèdoc and Graves regions of the Bordeaux area (Robinson J., 2012), especially in the famous well-drained gravels originating from the Gironde' river. From a census in 2009 it was the fourth most planted red variety in France with a total of 56386 hectares, and ranked second after Merlot in the Bordeaux region.

Cabernet Sauvignon is an important variety in Italy: it was introduced for the first time in 1820 in the Piedmont region and at the end of the twentieth century the variety was spread throughout the country, particularly in Tuscany, where it has an important role in Super-Tuscans wines, such as Sassicaia. In a census in 2010 the total surface of Cabernet Sauvignon was around 15795 hectares (Vivai Rauscedo, 2023); the variety has spread throughout north-eastern Italy, such as Veneto, Trentino Alto Adige and Friuli.

1.2.3 Morphological, phenological features and cultivation aptitudes of Merlot and Cabernet Sauvignon

The Merlot vine is characterized by different biotypes which, although belonging to the same vine variety, have some different morphological characteristics, in particular for the vigour and shape of the grape bunch (Vivai Rauscedo, 2023). The same morphological differences can also be present in

Cabernet Sauvignon vines, even if the variety is quite homogeneous compared to Merlot.

The two vines are both characterized by a medium-size and thick woody shoot.

The Merlot vines have pyramid-shaped bunches of medium size and compactness when ripe, with round berries with a homogenous blue-black skin, which is covered by hoarfrost, a waxy substance produced by the superficial cells of the epidermis of some fruits, which plays a protective action against ultraviolet rays and excessive dehydration. The thinner skin makes them more sensitive to rot, especially the grey one (Visan et al., 2020). The soft pulp inside is characterized by colourless juice with a neutral, sweet, slightly acidic and slightly herbaceous taste. In the case of Cabernet Sauvignon vines, the grapes are characterized by medium-small bunches when ripe with a cylindrical-pyramidal shape and medium compactness, often with a prominent winged bunch. Their spheroid and small berries with the thick and consistent blue-black skin are the distinctive features of this variety, in particular the thicker skin makes the grapes more resistant to rot; inside the berries there is a slightly fleshy colourless pulp with a sweet and slightly herbaceous taste (Vivai Rauscedo, 2023).

Figure 1. Merlot bunch on the left, Cabernet Sauvignon bunch on the right (Vivai Rauscedo, 2023).

The phenology of Merlot vine grapes is characterized by an early maturation, in fact they germinate, flower and ripen at least a week before Cabernet Sauvignon (Cosmo I.,1964); in particular their early flowering makes them more sensitive to late frosts and to coulure, a form of poor fruit setting in which the small berries fall, causing a drastically reduced yield if it occurs excessively (Robinson J., 2014). The grapes ripen in the third-fourth period, from the end of September to the beginning of October. The phenology of Cabernet Sauvignon grapes, on the other hand, is characterized by a slightly late budding and medium flowering. In this case the grapes ripen in the fourth period, in the first 15 days of October.

The cultivation aptitudes in the case of Merlot vines indicate a medium-high vigour, which includes the growth and overall development of the vine, not only as regards the physical size but also the balance between vegetative growth and fruit production, overall balanced in this case. The vines adapt to different soil types, except in very well-drained soils, especially in dry summers where the grapes remain underdeveloped. Different types of climates lend themselves to this specie, excluding excessively warm ones, in which the vines require frequent irrigations. Merlot vines usually need loose and warm soils, made up of rather coarse-grained elements such as sandy soil, permeable to air and water. But, on the other hand, despite Merlot's preferences for warm soils, their vines respond much better than Cabernet Sauvignon vines to damp and cold soils; in this case the soil retains its moisture better to supply the necessary water to the vines throughout the vegetative cycle to allow the complete development of the grapes. Thanks to its adaptability, Merlots are much easier to ripen than Cabernets and have the advantage of giving slightly higher yields. Also, for this reason, the area planted with Merlot is much higher than the area with Cabernet Sauvignon. However, unlike Cabernets, Merlots are extremely sensitive to the timing of harvest and, if harvesting is delayed too long, acidity levels can be dangerously low (Robinson J., 2014), which is a problem for what concerns the conservation of the wine and also its organoleptic balance. Cabernet Sauvignon is more vigorous than Merlot, it needs to be grafted on a weak rootstock to slow down the growth of the leaves (Robinson J., 2014); the green pruning technique is essential to create the right balance between vegetative development and grape production. These vines adapt best to warm, windy and dry climates to reach full ripening of the grapes and, depending on the location, they prefer good exposure with rocky and clayey soils on the hills, and well-drained soils on the plains (Vivai Rauscedo, 2023). The productivity is constant for both the vine species, but in the case of Merlot is much higher than Cabernet Sauvignon. The maximum production of grapes in tons per hectare is reported in the Product Specification of the Designation of Origin of the wines of the "Colli Euganei"; 13 tons/ha are reported for Merlot grapes and 12 tons/ha for the Cabernet Sauvignon grapes (Masaf, 2019).

The Merlot vines can be found with different forms of training systems, they are easily bred even in the totally mechanizable free forms; usually, these vines are trained on the espalier system with bilateral or single guyot pruning, which have in common the characteristic of having the supporting structure arranged horizontally and along the row. The guyot is suitable for hills, permeable and not very fertile soils and the pruning allows a fruiting head to be folded horizontally, while a spur that is a shortened grapevine cane, is left with 1-2 buds which will make up the fruiting head for the following year. The length of the pruning varies according to the age of the vineyard and the characteristics of the soil, in order to allow better quality productions, and Merlot vines prefer medium or long pruning with 4-5 or 8-10 buds, in which the vine manages to give more production (Vivai Rauscedo, 2023). Even the Cabernet Sauvignon vines adapt to different forms of training systems and pruning activities and, as in Merlots, are trained on the espalier system with guyot or spurred cordon; the latter is a form of short pruning which consist in the creation of a permanent cordon which occurs by bending a branch to the desired height, which is made to grow until it reaches the next plant (Robinson J., 2014). Pruning consists in removing the branches formed on the spurs, leaving 2-4 buds on them.

The two vine oppose different resistances to diseases; for example, Merlot vines are more sensitive to downy mildew, a fungal disease that attacks all the green parts of the vine and in this case in particular the bunch; it can manifest itself in pre- or post- flowering by showing a deformation of the terminal part of the bunch which takes on a brownish colour and subsequently, in high humidity conditions, the whole bunch will be covered with the characteristics whitish mould. Cabernet Sauvignon vines, instead, are susceptible to powdery mildew, a fungal disease that visibly affects all attached green parts with grey-whitish spores similar to ash (Robinson J., 2014) and if the bunches are affected before flowering it has a strong reduction in fruit set and yield. Cabernet Sauvignon is also sensitive to some wood diseases such as eutypa and excoriose, both of fungal origin, in which the young shoots are stunted and yellow with cupped leaves due to a toxin produced in infected trunks; the problem is that it is difficult to control by removing infected parts of the vine, as the spores can blow-in from other host plants. They don’t affect the quality of the wine but create drastic problems on yields (Robinson J., 2014).

1.3 The traditional red wine-making process of quality wines

The traditional red wine-making process is divided into several steps, in particular the phase that distinguishes it from white wine-making is the maceration process, responsible for all the visual, olfactory and gustatory features.

The first step is related to the mechanical operations on the grapes in the vineyard, starting from the harvest, which can be done by hand or with the aid of harvesting machines. For quality is useful to remove damaged grapes or those with a delay in ripening, already in the vineyard by making a careful selection or in a sorting table after the harvest. Furthermore, for the transport from fields to cellar is preferable to use small containers in order to premature crushing which can lead to uncontrolled fermentations. All these manipulations should be done softly to reduce tissues damages.

The grapes crushing is a wine-making operation of breaking the grape berries in order to make the juice more easily available to the yeasts which will start the fermentation (Robinson J., 2014). The advantage of this technique is to emphasize the dissolution of anthocyanins, natural phenolic glycosides responsible for the colour of black and red grapes, and tannins, a complex and diverse group of chemical compounds present in many trees and fruits responsible of astringency sensations (Robinson J., 2014), that can give to the wine a full structure body without aggressiveness or negative herbaceous tastes (Ribéreau-Gayon P., 2017); this is what can happen in some cases of a more vigorous pressing, in which the extraction of tannins is more consistent and tends to enhance unpleasant flavours such as negative astringencies.

Destemming is the technique of removing the stems from bunches of grape berries (Robinson J., 2014), since if they were crushed, they would release their tannin content in the wine. Furthermore, the presence of stems can give a dilution effect with the reduction of the intensity of the colour, because the anthocyanins present on the skins are absorbed by the woody surface of the stems (Ribéreau-Gayon P., 2017). Crushing and destemming are generally carried out together with the same equipment and nowadays the use of destemmer-crushing machines is more widespread, which eliminate the stems before crushing the grapes.

Must is ready to be transferred to stainless steel fermentation tank. There is an addition of small amounts of sulphur dioxide (SO_2), a gas with antioxidant, antioxidasic and antiseptic properties which is fundamental to inhibit the populations of indigenous yeasts and bacteria, to reduce oxidations that are wine faults resulting from excessive exposure to oxygen (Robinson J., 2014), to preserve sensory characteristics of the wine and to prevent the development of alterations or diseases caused by contaminants. This allows only the selected yeast to grow, chosen for its adaptability, temperature resistance and ability to conduct a complete fermentation. Active dry yeast (ADY, *S. cerevisiae*) is often used, correctly chosen from commercial strains; it requires reactivation in a mixture of must and water before inoculation.

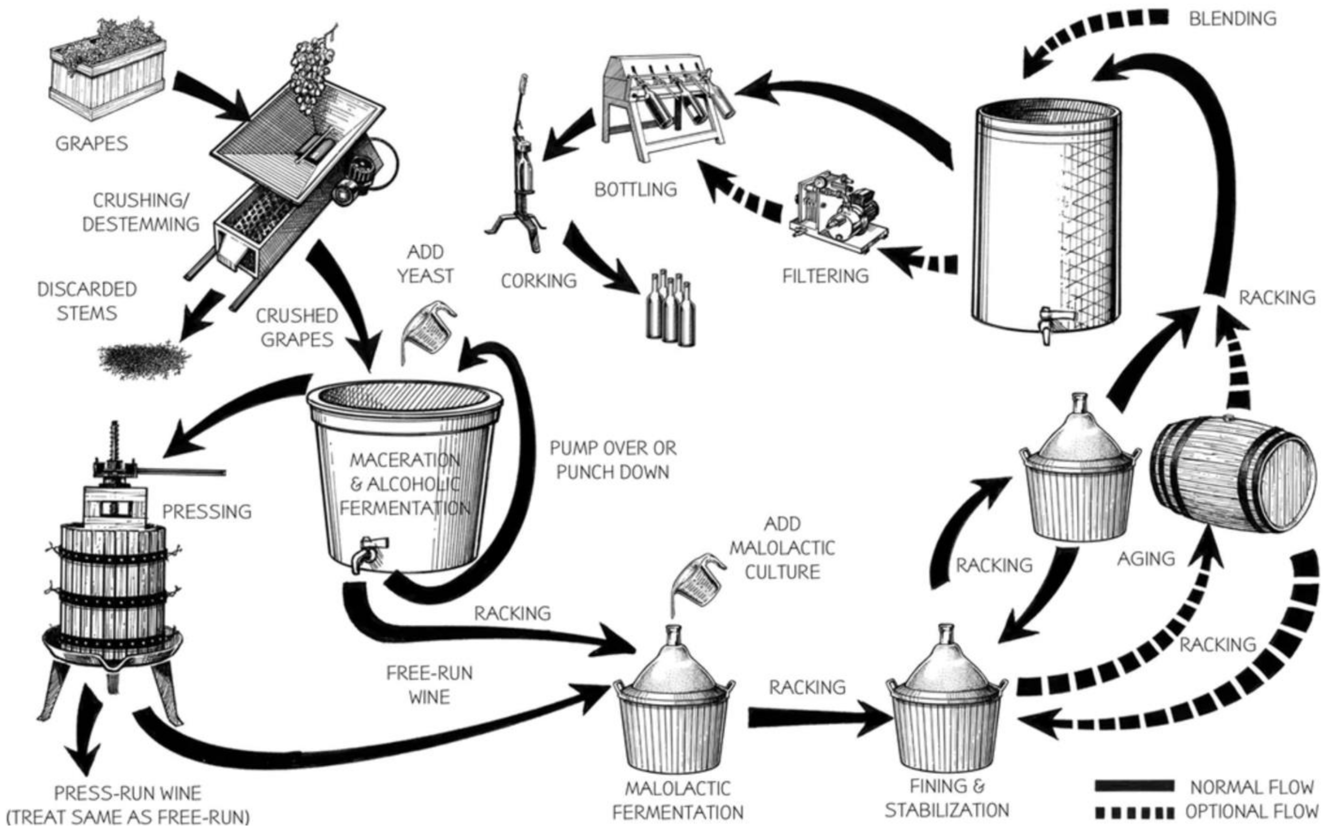

Figure 2. Flowchart of red winemaking process (Pambianchi, D. 2008).

The starting of fermentation causes an increase in temperature and the production of ethyl alcohol and carbon dioxide (CO_2). For this reason, is appropriate to leave empty the 20% of the total volume of the tank. The volume of CO_2 rises towards the upper part of the tank and the bubbles drag the solid particles to the surface which will form the pomace cap, held high thanks to the pressure of the gas developed.

The pomace plays one of the most important roles in the red wine-making, it releases its constituents such as anthocyanins and tannins, during the maceration process. It is very important to always keep the pomace completely immersed in the must, to prevent it from drying out. This operation can be carried out with pumping over, known as *remontage*, consists in draining the fermenting must from a valve placed on the bottom of the tank into a small container, if with aeration, and pumping the liquid onto the pomace cap (Robinson J., 2014). The aeration allows the contact between air and must that is essential for growing yeasts and their surviving (Ribéreau-Gayon P., 2017). Another method is the *délestage*, whit which the fermenting must is drained from the fermentation tank into a second tank which is filled up to the top and the remaining pomace is left to flow freely for a few hours. The juice is then pumped back over the top of the cap into the original tank through a low-pressure pump,

allowing for optimal diffusion of tannins, pigments and other substances from the fruit into the wine, reducing the extraction of bitter tannins (Robinson J., 2014).
The maintenance of pomace and must in contact, simultaneously with fermentation, allows the maceration, the extraction of constituents that contribute to the aroma and flavor of the wine. This extraction is facilitated by tissues destruction after crushing and by ethanol and heat formation during fermentation. Time, temperature, but also the degree of agitation of the pomace cap and the quality and ripeness of the grapes, regulate this process. Longer macerations with high temperatures (above 30°C) allow for stronger extractions, useful for high quality wines in which tannic richness is essential to ensure long ageing and, at the same time, must not compromise finesse and elegance of the product. On the other hand, shorter macerations at lower temperature (about 25°C) are useful for red wines intended to be consumed young in which it is important to maintain fruity aromas. Usually, the time can vary from six to ten days, or more (up to 40 days) for some Premium wines of great value, because in this case the lengthening of the duration allows the maturation of tannins which become softer, improving the gustatory features of the wine (Ribéreau-Gayon P., 2017).
The next step consists to drain the clear wine by gravity into a new tank to separate it from the lees composed of dead yeast cells. The solid parts like pomace can be pressed to extract the press wine; the latter is usually used to improve the quality of the free-run wine.
After the racking and during the beginning of the wine refinement, the malolactic fermentation takes place. It is a process characterized by a conversion of malic acid into lactic acid and carbon dioxide by lactic acid bacteria, naturally present in the must and reactivated through environmental conditions or selected bacterial strains belonging to the *Oenococcus* or *Lactobacillus* genera (Robinson J., 2014). The process tends to occur spontaneously, especially in red wines and in temperate or warm climates. This chemical process which consists of a simple decarboxylation with loss of acid function, is desirable in wines with excessive acidity, especially for reds from cooler climates (Robinson J., 2014), and is instead undesirable in wines to be bottled and sold young or vinified in white. The bacteria must participate when all the sugar has been fermented by the yeasts, since there are no more fermentable sugars, the bacteria will attack the more easily biodegradable and unstable molecule, i.e. malic acid. This type of fermentation is strongly influenced by the pH of the wine and the temperature. The best pH range is between 3.2 – 4.4 and the ideal temperature is 20°C. The results of the malolactic fermentation are the colour change of red wines, with a loss of intensity and an attenuation of the bright red tint. It gives greater aromatic complexity to the wine bouquet, especially when the lactic notes aren't excessive and improves the gustatory aspects of the product making it softer, more full-bodied, less acidic and less rough.

Finally, the wine maturation is the useful time for the product to harmonize its components and requires different time according to the wine to be obtained; for a young red wine it requires at least 3 months in stainless steel tanks, for more structured wines the time is longer, such as 5 or more years in wooden barrels or barriques, until it is ready for bottling. In any case, the fining of the wine will continue to evolve, even once it has been bottled.

1.4 The pedoclimatic and viticulture characteristics of "Colli Euganei" area

The "Colli Euganei", known as Padua Hills, are a group of conical hills of volcanic origin distributed in the south-west of Padua, in the Po' Valley, in particular between the municipalities of Abano Terme, Montegrotto Terme, Galzignano Terme, Arquà Petrarca, Torreglia, Due Carrare, Monselice, Este, Vo' euganeo, and others; all of these are located within the "Regional Park of Colli Euganei", an area of approximately 19000 hectares.

Figure 3. Map of municipalities of the "Colli Euganei" (*Parco Regionale dei Colli Euganei*, s.d.).

In this area the climates, the soils, the exposures, the slopes, the agricultural productions are different according to the specific zone. There is a great heterogeneity despite the limited extension of the territory, because the area planted with vines is very small compared to the total area, about 2500 hectares of vineyards in which the variability is very strong.
The climate in general is temperate, with mild winters, hot and dry summers, good temperature range between day and night; the phenomenon of thermal inversion is frequent, in which temperatures can be higher in hilly areas than in the plains, especially in the early hours of the morning and with clear skies, an optimal condition for cultivating vineyards (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014). The average annual rainfall fluctuates between 700 – 900 mm, especially in spring and autumn, and the relative humidity varies between the plains and the hills, where the values are considerably lower (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014). The vineyards are mostly located at altitude of 50-300 meters above the sea level.
On the basis of these characteristics, the territory can be divided into different zones: the northern zone which is characterized by a piedmont climate with luxuriant vegetation, good amount of rain and a maximum altitude around 250 meters. The eastern area is characterized by insolation in the morning hours, quite luxuriant vegetation, slightly less rainfall than in the north, and a maximum altitude of 200 meters. In the west, temperatures are warmer with radiation until sunset, the vegetation is very rich, the rainfall is not excessive and the altitude reaches 270 meters at maximum. The Central area, on the other hand, is characterized by the presence of the highest peak of the Padua Hills, namely Monte Venda (601 meters above sea level), which acts as a physical barrier to air currents coming from the north; temperatures are lower and rainfall higher. In this case the altitudes reach and exceed 270 meters. Finally, the southern area which is the hottest one characterized by a Mediterranean climate, with very little rainfall and a maximum height of 270 meters above sea level (Scortegagna F., 2022).
The differences in degrees Celsius on an annual basis between north and south can reach two degrees centigrade, which have a great influence from a botanical point of view (Scortegagna F., 2022). For example, as far as the vines are concerned, it has been found that Merlot grapes can have a phenological variability at budding of up to 18 days between the two opposite parts of the area, and the same is true for the harvest period, which can be anticipated up to 20 days in the southern area (Scortegagna F., 2022).
The soils of the area generally present good skeleton, good drainage, many minerals and trace elements deriving from their volcanic origin. Depending on the degree of disintegration of the volcanic rocks over the millennia, different types of soils emerge in the different hilly areas, for example vulcanite, made up of rhyolites, basalts, basaltic tuffs, whit a medium or medium-coarse

texture and a large quantity of nutritional elements, allows medium-high sugar content and good acid balance, that, together with a good exposure of the soil, allows obtain red wines characterized by an optimal maturation due to the right balance between sugars and acids. In Merlot wines but also in Cabernets, these conditions affect the sensory features, giving them notes of ripe fruit, cherry, small red fruits, spices, herbaceous notes, etc. Sedimentary rocks, instead, are ideal for structured, rich, consistent and highly prestigious red wines. The marls (sedimentary rocks) and alluvial sediments (alluvium conoids, alluvial valley floors) give good fertility to the soil to obtain high productions from a quantity point of view, with a slightly lower sugar and acid content; these types of soils are useful for young wines, especially those made from white grapes (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014).

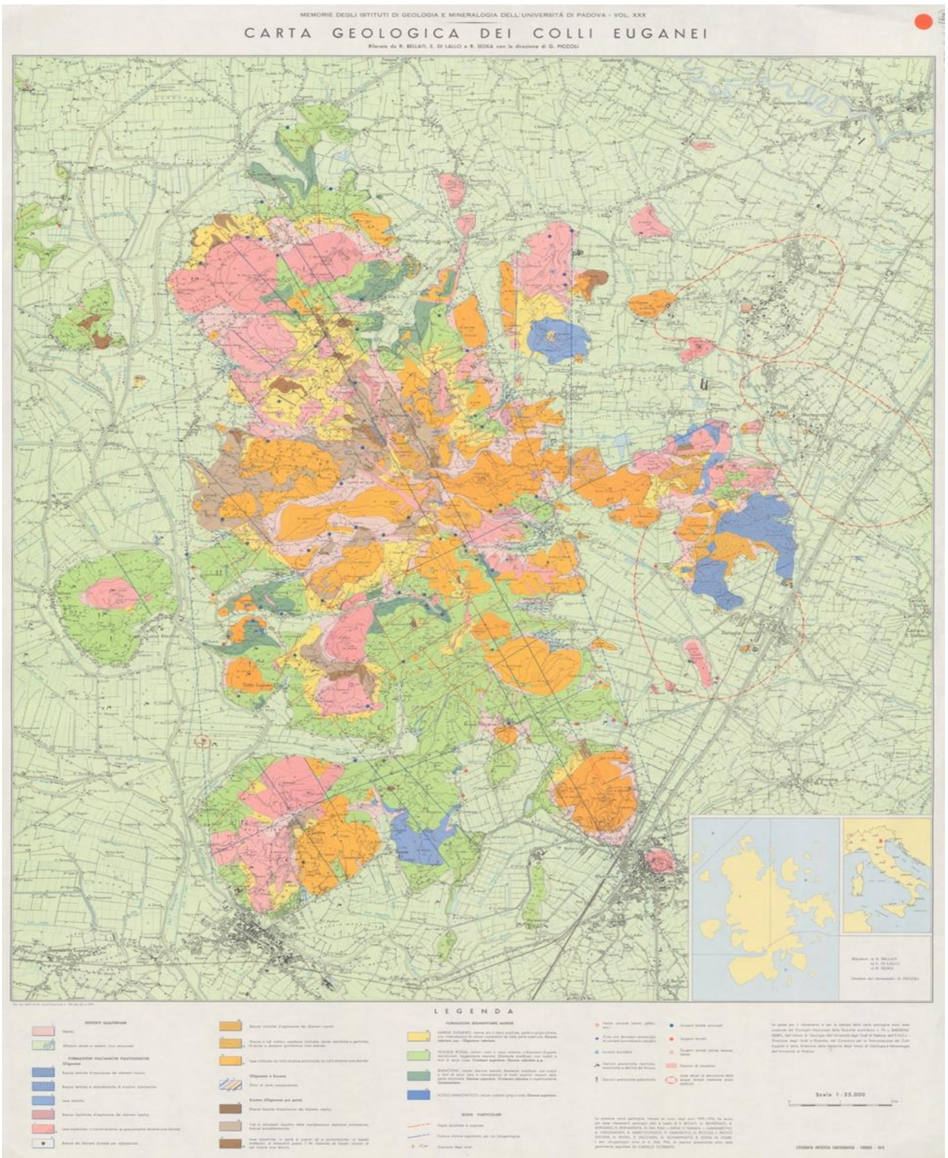

Figure 4. Geological map of the "Colli Euganei" (Carta geologica dei Colli Euganei. Firenze, Litografia Artistica Cartografica, 1975).

The combination of soil typology and climatic factors makes the Padua Hill a rich territory dedicated to the production of fine wines (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014). The coexistence between modern cropping systems and traditional ones is ordinary administration; traditionally the plains around the hills were cultivated with arable land and the vineyards were located on the slopes of the hills, placed on terraces and shoulders, but in some cases also on large flat plots (Giulivo C., 2018). The position of the land on the slopes allows the outflow of water avoiding stagnation and, depending on the exposure to the sun, the choice of the type of wine to be obtained varies; different exposures and dispositions tend to bring out specific qualities (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014), and they are also important to make the soil more adaptable to crops and to facilitate mechanical operations in the vineyards. In the case of Padua Hills, on the steepest slopes the land is arranged in steps supported by dry stone walls, which characterized the famous "heroic viticulture"; another typical arrangement is the "rittochino", one of the oldest in Italy, which divides the slope into rectangular units with the longer side arranged along the maximum slope line, where the slope does not exceed 20-30%; its main advantage is the ease of mechanization for cultivation operations, even if the defense against erosion is compromised (Giulivo C., 2018).

The typical training systems used in the "Colli Euganei" are Guyot and Sylvoz. There are several variations of Guyot which have two opposite slightly curved fruit heads. The Sylvoz, on the other hand, is an espalier system with a permanent cordon on which arched fruit heads are formed; it is an expanded form characterized by long and rich pruning, suitable for vigorous vines because it ensures good quality for the grapes and constant production for the vines (Giulivo C., 2018).

From history we get some evidence of viticulture in the "Colli Euganei"; in 1942 the province of Padua was the area with the highest wine production in the Veneto region (Giulivo C., 2018). The Merlot and Cabernet Sauvignon vines were imported for the first time after the 1850, by the nobles who lived in this area (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014). The two varieties have adapted to the soil and climatic conditions, in particular the Merlot was the most cultivated red grape variety in this area, immediately appreciated by local winemakers for its constant production and early ripening (Giulivo C., 2018).

Over the years the landscape of the Padua Hills has changed a lot. The economic interest in viticulture has led to the reduction of the woods to exploit high-value exposures for the cultivation of the vine, but, despite the great urban development of the area, the landscape has maintained a good biodiversity. One of the most important things is to exploit the soil and climatic characteristics of the place and the technical innovation in the wine sector together with the specific skills of the producers to obtain the maximum expression of the potential of the vines. The producers continued to qualify the product and in 1969 the wines of the "Colli Euganei" obtained the recognition of the "DOC Colli Euganei", the Controlled Designation of Origin, a specific denomination which certifies the area of origin of the product. Today, this denomination is enhanced by the "Strada del vino Colli Euganei" (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014).

1.5 Sensory aspects of wines

1.5.1 The sensory characteristics

Sensory characteristics refer to the attributes or properties of products that can be perceived by the five senses which are sight, taste, smell, touch and hearing; in particular the first three senses have the most important role in sensory perception.

Every sensory stimulus, which is a chemical or physical activator that create a response in a receptor, produces some sensation that are transformed in perceptions. Sensation is what is perceived at the cortical level when a receptor is stimulated and perception is the action by which one becomes aware of a stimulus caused by sensations. The sensory receptors are the structure able to react to stimuli and are specialized in the recognition of single classes of optical, thermal, chemical or mechanical stimuli (Pagliarini E., 2021). The stimulus must exceed a certain energy level, called absolute threshold of perception, to produce a sensation (Pagliarini E., 2021).

Visual perception involves the eye and what we see with it. Colour is one of the first parameters that helps us identify the characteristics of the product and its quality (Pagliarini E., 2021); in the case of wine, it is the first sensory aspect to be evaluated. In detail, the ocular area used to recognize colour is the retina.

The sense of smell, together with sight, allows our first reaction towards wine. The receptors are located in two portions of epithelium in the nasal cavity (Pagliarini E., 2021) and the substances responsible for the aromas are absorbed through the mucus, allowing their perception. On the bases of the canal concerned are distinguished orthosanal and retronasal perceptions. The first are those that are perceived directly through the nose while the second are the olfactory sensations perceived in the mouth when the product is introduced into the oral cavity, through the chemical stimulation of the olfactory epithelium. These perceptions are grouped in the term *flavour* (Pagliarini E., 2021) which indicates a mix of sensations such as taste, smell but also thermal or irritating sensations. Smell is characterized by low substrate specificity because there aren't specific receptors for specific odorant molecules. The most important thing is that the substances are volatile, easily present in the gaseous

state, in order to be perceived as odors. The receptors recognize the substances and transmit the signal to the olfactory bulb, which in turn transmits it to the brain, which will associate the perception of that molecule with a specific smell.
Taste perception involves the tongue, an organ made up of taste receptors located within the cell membranes of modified epithelial cells, which create synaptic connections with the main nerves of taste. Flavors such as sweet, bitter, sour, salty and umami are perceived homogeneously on its surface (Pagliarini E., 2021). The presence of saliva is necessary for the gustatory response, but also to transport the sapid molecules to the receptors and to modulate some tastes thanks to some substances it possesses (Pagliarini E., 2021).

1.5.2 The factors affecting the sensory evaluation

The sensory evaluation is the basic tool for assessing the quality and safety of a product. It uses human senses to evaluate the appearance, aroma, taste, texture, etc., to improve quality control, product development, to understand consumer preferences and differentiate products in the market. The choice of the method to be used in sensory analysis is the most important thing, and today it takes place through the standard procedures that have been developed over the years by expert analysts. The evaluation can involve a panel of trained people who provide detailed and accurate descriptions of a product or simple consumers as judged with no experience but who are very useful if you want to understand consumer preferences for the development of new products in the market.
There are large inter-individual differences on the sensory perception because each individual has different olfactory abilities and personal preferences due to their genetic heritage and the social and cultural contest in which they find themselves. It is very difficult to reach total agreement in a sensory analysis also because our senses are limited in their ability to analytically recognize many compounds present in a mixture (Pagliarini E., 2021) and for this reason many lists of smells and tastes have been developed, such as the wheel of *flavours* used in sensory evaluations of wine.
The factors that can most compromise the evaluation skills of the judges are represented by psychological and physiological errors, which often occur when judges are inexperienced. It is important to recognize these errors and minimize them (Pagliarini E., 2021).
Psychological errors include the error of the tendency towards the central value which occurs when the judges tend to give scores in the central band of the scale, excluding the extremes (Pagliarini E., 2021). The amplitude of the scale is reduced and the scores will be very similar to each other, resulting in the flattening of the judgment. This type of error can be avoided with a well-balanced presentation

order, randomized from judge to judge and from session to session, and with a training period to familiarize judges with the scale and the product to be evaluated.

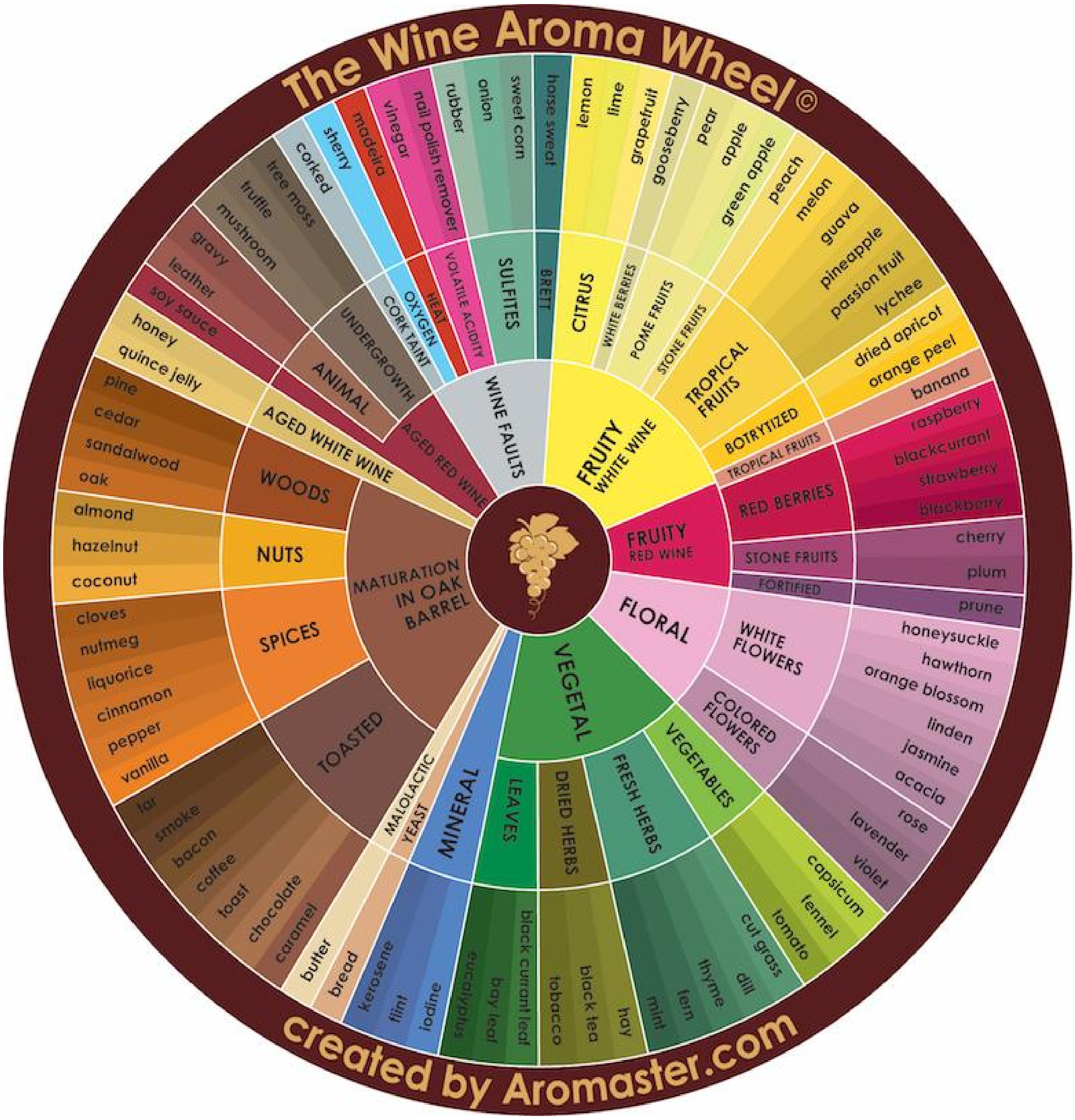

Figure 5. The wine aroma wheel («Wine Aroma Wheel by Aromaster, s.d.)

The presentation error, instead, occurs when the first product evaluated tends to obtain higher scores than one might expect; the problem arises from the order in which the products are presented, which is why it is necessary to randomize the judges and the sessions and make sure that every possible combination is present the same number of times (Pagliarini E., 2021). Other errors are related to expectations and occur when the judges know the product and its characteristics; in this case it’s useful to exclude these people from the session. The presence of other stimuli such as the color or shape of the box containing the product, etc., can be a problem for the evaluations and the judges can find differences that do not actually exist. It is always necessary to anonymize the samples. Other psychological errors are errors of anticipation and errors of closeness; in the former the judges perceive the stimulus before it reaches the effective threshold of perception, compromising the final result and in the latter the judges can be confused by some attributes with analogous meaning and tend to be evaluated in the same way (Pagliarini E., 2021).

Physiological errors include errors of adaptation due to a temporary modification of the sensitivity of the sensory receptor due to continuous and repeated stimuli. In the case of wine, it is in fact necessary to take breaks between one evaluation and another, to avoid confusing the aromas between one sample and another. Further errors are related to the different perception threshold present in the different judges who should be able to understand their perception threshold of sensory stimuli. In other cases, judges may lose the ability to perceive all odors or a specific odor due to the loss of the specific receptor useful for detecting that odor.

The best way to minimize all these types of errors is to do a correct interpretation. It consists in not evaluating the sensory data by looking only at the statistical elaboration but considering the entire experimental context; it is useful for establishing whether the differences detected really depend on differences found in the samples or if they derive from errors made during the evaluation.

Sensory evaluations must be carried out in suitable environments to obtain scientifically valid results, without the presence of disturbing elements such as smells, voices, lights that can psychologically influence the judges giving rise to errors. The most suitable environment included tasting booths isolated from each other to avoid any form of external interference and confrontation between the judges. It should be mandatory to respect silence during the evaluation and pre-establish an area for a subsequent collective session in which the results can be discussed instead.

On the basis of the methodology applied for sensory analysis, the careful choice of the number and type of panelist to be used is important; it is possible to recruit inexperienced judges (general consumers), judges already trained in sensory evaluations or judges trained in preliminary sessions for the specific analysis they will have to carry out (Pagliarini E., 2021).

1.5.3 The descriptive method

The International Standard UNI EN ISO 13299:2016 provides guidelines for the overall process of defining a sensory profile (ISO Standard, 13299:2016). These methodologies describe the sensory characteristics perceived in a product to quantify the differences between products, identify the variability of the process and determine which attributes are fundamental for the acceptability of the product itself (Pagliarini E., 2021).

Usually, the descriptive method makes use of collective session of 8-12 judges who assign scores to the various descriptor, such as visual aspects, smell, taste, tactile sensations in the mouth, consistency, attributing a score according to a pre-established scale, to obtain the sensory profile of the product. The purpose is to obtain objective description. It can be accomplished with terms which describing the perceived stimulus, such as specific aroma, or the perceived sensation, such as sweet or sour.

The first thing to do is the qualitative analysis, which consists in developing a vocabulary of sensory descriptors suitable for the product in question; it is defined by reaching an agreement among the judges of the tasting group and it is essential to avoid confusion among them, in order to obtain the more homogeneous results. The next step is the definition of the reference standard for each descriptor, corresponding to the maximum intensity value on the evaluation scale used (Pagliarini E., 2021). Quantitative analysis, on the other hand, consists of the judges rating the intensity of each descriptor. Finally, the last step consists in the statistical elaboration and in the interpretation of the obtained data. The best thing to do is to replicate the analysis on several different days and all the final scores obtained will then be analyzed using ANOVA (analysis of variance), in which the total variability of the data is distributed among the various factors to evaluate the effect (Pagliarini E., 2021). The variants to consider are the samples, judges and replicas. The test makes it possible to evaluate whether these factors are significantly different from each other.

This type of descriptive method is called *Quantitative Descriptive Analysis* (QDA) and the final results are represented in graphical form (spider plot) with the mean value of each intensity value of the different analyzed descriptors placed on unstructured axes arranged radially in the plane. All the values are fixed on the axes and are joined together by means of broken lines that will give shape to a star figure.

1.5.4 The sensory features of Merlot and Cabernet Sauvignon wines

Merlot wine is characterized by fairly intense but perceptibly lower ruby colour than Cabernet Sauvignon which has instead a thicker and distinctly blue skin, which gives the wine an intense ruby red colour tending towards purplish; therefore, the Cabernets are able to produce wines with an intense color worthy of long maceration and a long-term ageing in wood (Robinson J., 2014). Some of the distinctive traits of Cabernet Sauvignon that distinguish it from all the other varieties are the high seed/flesh ratio with the high tannin content (Robinson J., 2014) and the remarkable concentration of phenols.

Merlots have slightly lower acidity than Cabernet Sauvignons and are considered “smooth”, like a Cabernet without “pain”, understood as a less astringent wine due to the low tannin content (Robinson J., 2014). Astringency is an important parameter for the wine texture, it refers to physical sensations perceived in the mouth such as thickness and viscosity of the wine or roughness or softness of the tannins, but also to the perceived body, intended as an overall mouthfeel and to the tactile sensations experienced on the palate.

The wines aromas can be classified into primary aromas, which are the varietal aromas linked to the vine, secondary aromas, linked to the fermentation processes, and tertiary aromas, which are acquired by the wine during its maturation and ageing.

The two varieties give wines that show great similarities regarding the varietal aromas such as fruit aromas, for example in both are find aromas of red fruits, cherry, plum, strawberry, red or black currant, blue raspberry, etc. Generally, the fruity aromas are due to the presence of esters, organic compounds produced by the reaction of an alcohol or a phenol with a carboxylic acid or its derivative and which at low concentration have the characteristic odor of fruit. They are typical products of fermentation.

Floral aromas, on the contrary, derived from terpenes, a class of natural organic compounds whose structure is based on the repetition of isoprene units, which are aliphatic hydrocarbons; terpenes are found in vegetable resin and in essential oils extracted from plants, substances that give flowers their characteristics odors (Slaghenaufi et al., 2022). In Merlot and Cabernet Sauvignon wines it’s easy to find the scents of rose and violet which derived from specific chemical molecules intrinsic to the fruit.

Merlot wines have slightly herbaceous aromas compared to Cabernet Sauvignon wines, in which however vegetable aromas are present in higher proportions. These aromas are linked to different molecules such as 1-hexanol and 3-methylthiopropanol (Zhang et al., 2023); in detail, 1-hexanol is linked to herbaceous aroma and the 3-methylthiopropanol is linked to aromas of potatoes, cooked cabbage, cauliflower. In the specific case of Cabernet Sauvignon, the green notes in some cases recall green peppers, whose aroma derives from pyrazines (Zhang et al., 2023), heterocyclic aromatic organic compounds with a pungent and sweetish odor often present in the Cabernet Sauvignon variety.

The secondary aromas are similar in both Cabernets and Merlots; it is easy to find malty taste, buttery and creamy aroma, linked for example to the malolactic fermentation. These notes derive from alcohol molecules such as 2,3-butanediol and 3-methyl-1-butanol (Bartowsky & Henschke, 2004).

Tertiary aromas, on the other hand, are normally developed from acetalization, esterification and oxidation processes of alcohol molecules, tannins, acids and many other substances. For both wines varieties there are spicy aromas such as pepper, cinnamon, cloves, nutmeg and vanilla, toasted aromas such as coffee, smoke, cocoa and some aromas related to animals such as wild smell, sweat, and leather (Wang & Spence, 2018). This class of aromas is linked to the type of ageing to which the wine is subjected.

2. Aim

This thesis is a part of the activities of a large project focused on Super/Ultra-Premium red wines curated by CIRVE (Interdepartmental Center for Research in Viticulture and Oenology) and University of Padua, in collaboration with Coldiretti and the Consorzio Volontario per la Tutela dei Vini Colli Euganei. This project aims to outline viticultural and oenological protocols suitable for the production of Premium red wines international Bordeaux grape varieties, namely Merlot and Cabernet Sauvignon, and to obtain data that will allow to propose a "Protocol of Designation" functional to a differentiation "toward excellence" of red wines coming from the different areas of the “Colli Euganei”. To this aim, eleven wine producers located in the five different areas of the Padua Hills were asked to follow a common protocol for both the viticultural and oenological aspects, with the aim to produce Merlot and Cabernet Sauvignon wines with quality levels in the line with internationally recognized standards, also through a good capacity to understand, discuss, and communicate the sensory dimension of wine and its determinants.

In this framework, this thesis aimed at characterizing, from the chemical and sensory point of view, eleven Merlot and eleven Cabernet Sauvignon wines produced in vintage 2022 following common protocols, with the final aim to trying to understand which are the main variables that can influence the sensory profile of wines.

3. Materials and Methods

3.1 Vineyards locations and the suitable cultivation systems for the two varieties

Several producers of Merlot and Cabernet Sauvignon wines from the Padua Hills were contacted in order to obtain their availability in participating in the project. The conditions to their participation was that they would have needed to provide monovarietal wines from grapes coming from single vineyards located in different sub-areas of the "Colli Euganei".

Eleven wineries gave their availability (Table 1), each one producing one Merlot and one Cabernet Sauvignon, and the location of the vineyards considered is shown in Figure 6.

Table 1. Table of companies participating in the project.

WINERY CODE	WINERY NAME
MRB	Tolomei Mirabello
PNZ	Il Pianzio
SLV	Salvan - Vigne del Pigozzo
BRN	Borin Vini & Vigne
LRG	Vini Loreggian
BRB	Barbiero
ALV	L'Alveare
CLN	Bacco e Arianna
CRP	Carpanese
FRS	Farasin
VO'	Cantina Colli Euganei Vo'

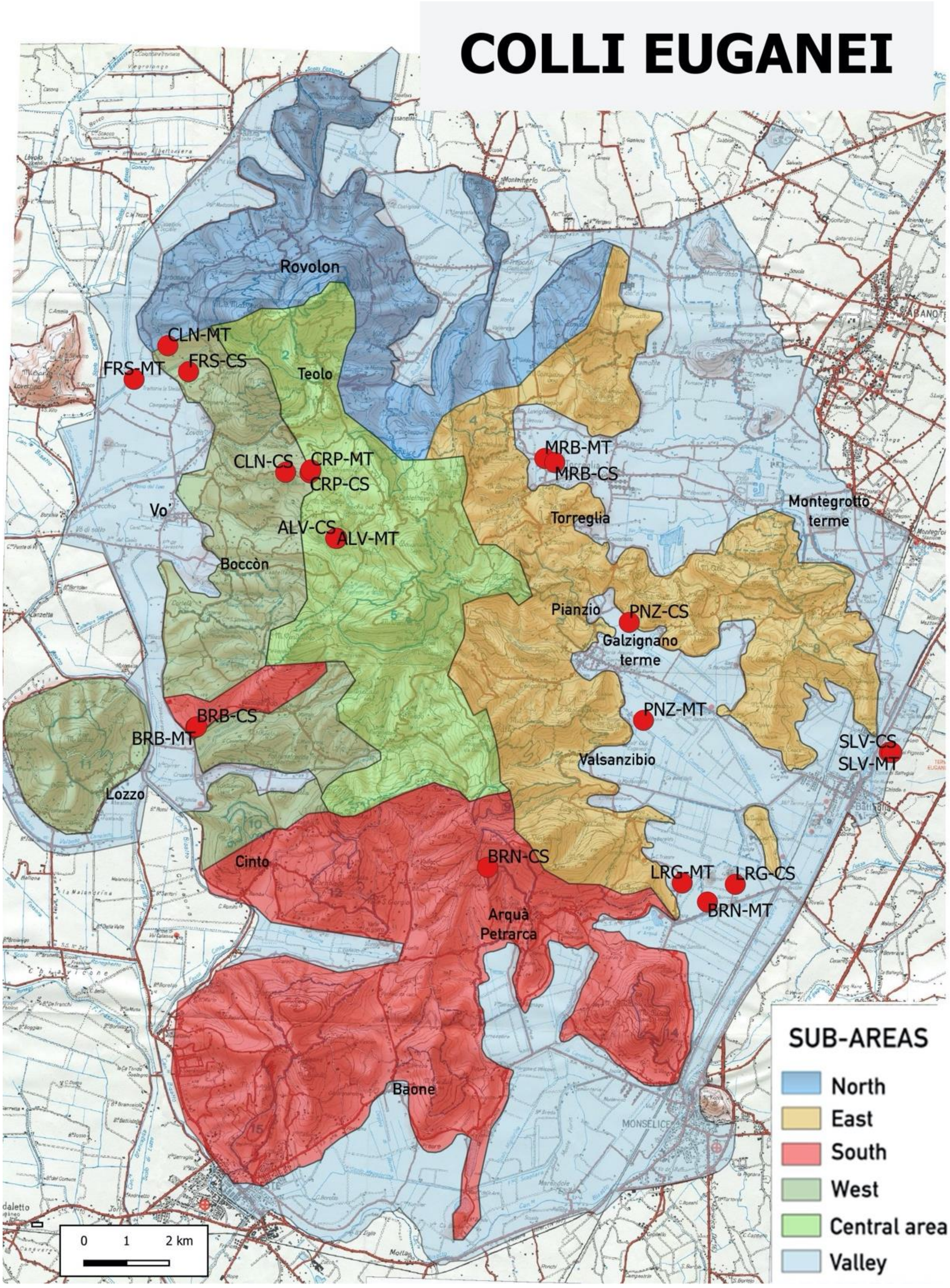

Figure 6. Map of Merlot (MT) and Cabernet Sauvignon (CS) vineyards.

The scientific technical committee, consisting of some CIRVE members, expert technicians of the area, and representatives of the Consortia of "Colli Euganei" wines, "Colli Euganei" Cellar and of the Community of Producers, met in June and August 2022 to define the guidelines of the working protocols about the viticultural and especially oenological aspects to reach the qualitative standards internationally recognized for the production of Premium red wines from international Bordeaux varieties.

The areas were located in the five sub-zones, but also including plains, foothills and hills. In detail, for all the eleven wineries, the vineyards owned by MRB winery are located in the eastern foothills for both the Merlot and Cabernet Sauvignon vines, and the same also applies to the Cabernet Sauvignon vines of the LRG winery; but, in this case, its Merlots are located in a flat area always to the east. Most of the vineyards planted with Merlot are cultivated in flat areas, such as those of the PNZ, SLV, BRN, and FRS wineries; the first three vineyards are located in the eastern area and the last one on the opposite side, in the north-west. For the Cabernets, on the other hand, only those owned by PNZ and SLV are found in the flat area of the eastern slope. The rest of the vineyards are mainly located in hilly areas, such as the Cabernet Sauvignon and Merlot vines from the BRB, ALV, CLN, CRP wineries, and for the Cabernet Sauvignon vineyards from the BRN and FRS wineries. All of these are located on the central area, close to the western side of the hills, with the exception of the BRN winery which owns the vineyards used for Cabernet Sauvignon in the southern area. Generally, as can be seen from the map of figure 6, the same wineries have their own vineyards in fairly close areas, regardless of the variety in question.

Being all from private produces, all vineyards were managed according to companies' choice, and as such they differed in terms of planting system, the age of the vineyards, the number of plants per hectare, the rootstock, the orientation of the rows and the altitude above sea level. For this last parameter, the vineyard planted with Cabernet Sauvignon located at the highest altitude is that owned by the BRN winery at 200 meters, followed by the Merlot and Cabernet Sauvignon vineyards of the ALV winery located at 195 meters above sea level. On the contrary, those situated mostly on the plains are those with the lowest altitude, around 4-5 meters above sea level, such as the vineyards owned by PNZ, SLV and LRG wineries.

The training systems used are mainly the spurred cordon, followed by the tipped or double tipped one which derives from the Guyot and has two spurs and two grape shoots tied in an arch (Giulivo C., 2018), and finally also the guyot and sylvoz training systems.

The activities connected to the vineyards such as soil management, canopy management, and especially harvesting time were coordinated by the scientific technical committee with the aim of achieving the conditions established by the testing protocols, by collecting data regarding phenological characteristics such as influence of the climate, ripening of the grapes, and chemical and sensory analysis of both the must and the wine produced.

Table 2. Analytical parameters for Merlot wines. Analyzes carried out by the laboratory of the "Consorzio dei Colli Euganei" in November 2022 and May 2023.

SAMPLE	Degree % vol	Sugars % p/v	Volatile g/l	Total acidity g/l	pH	Potassium g/l	Total So2 mg/l	Free So2 mg/l	Malic g/l	Lactic g/l	Tartaric g/l	Total extract g/l	Net extract g/l	Total polyphenols mg/l	Anthocyanins mg/l
ALV	13,90	0,2	0,67	5,30	3,60	1,15	50	28	0,05	0,50	2,9	30,7	28,4	2946	316
BRB	12,35	0,2	0,65	6,05	3,36	0,93	20	12	0,06	0,75	3,4	28,7	23,3	1500	173
BRN	14,25	0,2	0,55	4,90	3,57	1,14	60	28	0,01	0,35	2,95	29,7	27,6	2320	137
CRP	14,00	0,2	0,43	4,50	3,85	1,04	50	18	0,05	1,50	3,1	29,5	27,5	2100	231
PNZ	13,90	0,2	0,44	5,20	3,64	1,2	36	20	0,02	0,80	2,2	30,0	27,9	1945	230
MRB	14,10	0,2	0,38	6,25	3,36	0,98	40	20	0,76	0,20	3,9	29,5	27,5	2330	353
CLN	13,60	0,2	0,70	5,25	3,70	1,18	30	16	0,02	0,90	3,4	32,0	29,9	3075	420
LRG	13,10	0,2	0,45	4,15	3,67	1,3	30	16	0,02	0,40	2,9	25,5	24,2	1678	160
SLV	13,75	0,2	0,75	5,50	3,57	1,05	32	16	0,05	1,00	2,5	27,8	25,8	2462	225
FRS	14,50	0,2	0,65	3,90	3,89	1,4	40	16	0,05	0,35	3	27,9	25,8	2163	276
VO'	12,70	0,21	0,38	4,50	3,60	/	/	/	0,01	0,50	/	27,6	25,5	/	/
AVERAGE	**13,65**	**0,2**	**0.55**	**5,04**	**3,62**	**1,14**	**39**	**19**	**0,10**	**0,66**	**3,0**	**29.0**	**26,7**	**2252**	**252**

Table 3. Analytical parameters for Cabernet Sauvignon wines. Analyzes carried out by the laboratory of the "Consorzio dei Colli Euganei" in November 2022 and May 2023.

SAMPLE	Degree % vol	Sugars % w/v	Volatile g/l	Total acidity g/l	pH	Potassium g/l	Total So2 mg/l	Free So2 mg/l	Malic g/l	Lactic g/l	Tartaric g/l	Total extract g/l	Net extract g/l	Total polyphenols mg/l	Anthocyanins mg/l
ALV	13,05	0,2	0,85	5,20	3,68	1,25	80	32	0,01	0,70	2,75	31,0	29,3	2800	287
BRB	12,30	0,2	0,57	5,20	3,47	1,14	30	14	0,08	0,70	2,65	28,3	26,6	1620	174
BRN	14,45	0,2	0,58	5,35	3,58	1,18	60	32	0,02	0,90	3,75	31,3	29,3	2930	320
CRP	13,80	0,2	0,42	4,45	3,80	1,4	90	20	0,05	1,00	2,3	28,9	26,8	2347	267
PNZ	13,05	0,2	0,55	5,50	3,62	1,4	30	18	0,02	1,05	3,25	31,5	29,3	2470	359
MRB	13,70	0,2	0,78	4,35	3,80	1,36	40	16	0,02	1,00	2,4	30,0	28,1	2620	282
CLN	13,50	0,2	0,60	5,00	3,90	1,4	54	24	0,05	1,00	2,45	36,0	34,2	2575	388
LRG	13,50	0,2	0,45	3,90	3,78	1,25	40	16	0,02	0,70	2,55	28,9	26,8	1465	170
SLV	14,00	0,2	0,78	4,95	3,80	1,2	36	18	0,02	1,00	2,65	30,5	28,5	2495	230
FRS	14,45	0,2	0,55	4,10	3,97	1,57	50	16	0,20	1,00	2,68	30,0	27,9	2500	330
VO'	13,00	0,2	0,50	4,50	3,65	/	/	/	0,02	1,05	/	28,1	26,1	/	/
AVERAGE	**13,52**	**0,2**	**0,60**	**4,77**	**3,73**	**1,31**	**51**	**21**	**0,05**	**0,92**	**2,74**	**30,4**	**28,4**	**2382**	**281**

3.2 Degree of ripeness of the grapes, the harvest and the pre-fermentation operations

The shared protocol for the project involved measure the degree of ripeness of the grapes to determine the optimal harvest date. The grape samples were collected starting from mid-August, checking the pH, the total acidity, represented by the sum (in concentration) of all the fixed and volatile acids of the wine and expressed in tartaric acid (the most present in grapes), and sugars, such as glucose and fructose expressed in degrees Brix, which indicates the percentage of sugar in the must expressed in weight (kilogram sugar/quintal of must) and is important for predicting the future alcohol content after fermentation of the must (Robinson J., 2014). The benchmarks established for both Merlot and Cabernet Sauvignon grapes were pH range of 3.3-3.4, 6-6.5 grams per liters of total acidity and 23-24 °Brix for sugars.

The particular climatic conditions which characterized the 2022 affected the harvest because the summer season and the following autumn were very dry and hot, to the extent that there were 1.4°C more than in previous years (Arpav, 2023). This has led to the application of emergency irrigation in most of the vineyards of the eleven companies involved in the project. Some of the wineries have anticipated the harvest date earlier due to the early maturity of the grapes, such as, for example, for the Cabernet Sauvignon vines of ALV and for the Merlot vines of MRB and PNZ wineries.

The harvest was done manually, where possible, with the careful selection of the healthiest grapes, or mechanically, in which was recommended the use of dry ice (carbon dioxide in a solid state); its temperature at atmospheric pressure is extremely low (-78°C) and counteracts the oxidative and fermentative phenomena that can occur during transport from the vineyard to the cellar (Moreno-Pérez et al., 2013). This technique creates a protective atmosphere which preserves all the characteristics of each berry in the bunches. The data collection during the harvest concerned the yield per vine, the average weight of the bunches, the average diameter of the berries, the sugars, the acidity, the pH, the polyphenol total index which indicates the presence of chemical substances consisting of phenol such as anthocyanins, tannins and other aromatic compounds (Robinson J., 2014) and the leaf area index which describes the amount of leaf area per unit horizontal surface area on the ground (Yan et al., 2019), used to measure the surface area of the side of the leaves facing the sun which can therefore provide information on the storage of CO_2 by plants.

Before the fermentation process, some operations were carried out such as complete crushing-destemming, the minimum addition of sulfites, about 10-15 mg/L of SO_2 (or 20-30 mg/L of metabisulphite) as antioxidant and antimicrobial agents, an addition of 10 g/hL of enological tannins with antioxidant action. For the Merlot vines, and in the companies where it was possible, a cold maceration lasting two to three days was applied, in conditions of 10°C, saturation with dry ice and with a couple of light pumping overs per day. The low temperatures cause the rupture of the cellular tissues on the skins which release further aromatic components that enrich the must and prevent the action of those enzymes which start the alcoholic fermentation which is thus consequently delayed avoiding the risk of degradation of polyphenols (Aleixandre-Tudo & Du Toit, 2018).

3.3 Winemaking protocol

The protocol shared by the eleven producers is useful for obtaining comparable products that can give indications on the oenological potential of the grapes from vineyards located in the various sub-areas of the Padua Hills.

If it was necessary, some modifications of the composition of the must were considered permitted, above all as regards the acidity, possibly corrected with the addition of tartaric acid to reach the expected standard values. The same was true for the addition of some yeast nutrients in order to reach the value of 250 mg/L of YAN (Yeast Assimilable Nitrogen) which is the set of ammonium ions, primary amino acids and small easily assimilable peptides (Robinson J., 2014). As far as sugars are concerned, however, the protocol stipulated that no changes were necessary.

Fermentation took place in stainless steel or cement tanks, followed by two *délestages* in the first 3-4 days and some closed pumping over. Where possible, fermentation temperatures were controlled at around 26°C.

Malolactic fermentation was applied to all Merlot and Cabernet Sauvignon wines, except when the malic acid content was too low to cause problems. Selected bacteria were used to standardize the process.

After fermentation, maceration continued in a closed tank for 3-4 days with one pumping over per day, in CO_2 saturation to avoid oxidations. For most of the eleven wineries, the pre-fermentation and fermentation maceration lasted a total of 12-15 days.

Through the tasting, after the maceration, the optimal moment for the racking was chosen. The pomace was pressed with a pneumatic press and the pressed wine was separated from the free run wine. The clarification was carried out by static settling and racking, without the use of adjuvants.

The chemical analyses of the 22 wines were carried out in November 2022 and in May 2023, by the laboratory of the "Colli Euganei" Consortium, finally followed by a technical tasting in the presence of the technical committee and some of the wine producers.

After the first round of analysis, in November 2022 common guidelines for the management and maintenance of the wines during the refinement phase were agreed. The wines, both Merlot and Cabernet Sauvignon, were kept in 54 liters demijohns, completely filled to avoid oxidation. A passage in wooden barrels was not foreseen so not to mask wine sensory properties due to different wood characteristics. The wines were maintained at cellar conditions (14-18°C with average humidity between 75-80%). The established fining of the wines lasted about a year with the aid of some decanting to ensure cleanliness, color stabilization and to contain the problems of reduction, a chemical reaction opposite to oxidation due to lack of aeration, in which an element acquires

electrons; if the reduction is excessive it determines the slow polymerization of the tannins and the sulfur compounds present, following the reduction, can cause olfactory defects such as those reminiscent of rotten eggs, garlic, struck flint, cabbage, rubber etc. (Robinson J., 2014).
Finally, at the end of their refinement, the wines were bottled and closed with a technical cap to standardize the product and use it for subsequent analyzes and tastings to establish the evolutionary potential and longevity of the aromatic and phenolic profile.

3.4 The sensory analysis

3.4.1 The first training session

The thesis work began with the identification of the main sensory descriptors of Merlot and Cabernet Sauvignon wines through the scientific literature. Most of them were common for both wines. These were: floral, rose, violet, fruity, red fruit, cherry, prune, strawberry, apple peel, banana, citrusy, lemongrass, acidic, malted, buttery, honey, caramel, green and herbaceous, green pepper, peppery, clove, cinnamon, and nutmeg. Some descriptors were found mainly in Merlot, such as red currant, raspberry, pineapple, peppermint, vanilla, and parsley notes, while others were found mainly in Cabernet Sauvignon, such as dry prune, black currant, blue raspberry, pear, orange, cooked potato, cooked cabbage, almond, fungi notes and pine scent.
The purpose of the first training session was to select a limited number, among the many descriptors, of the most representative and easily recognizable ones in Merlot and Cabernet Sauvignon. The session was carried out with a group of eight expert panelists who were trained through the recognition of ten representative samples of aromas. The eight judges were made up of two women and six men, in a very wide age range, from approximately 25 to 70 years old.
The ten samples used in this session were derived from some sensory descriptors found in the literature and were aromas of banana, strawberry, apple peel, lemon, orange, black pepper, clove, rose, peppermint and pear.
The aromas have been prepared using the respective substances mentioned above, for example simple apple peel, black pepper in grains, cloves, peppermint. A pear puree was used for the pear aroma and for the strawberry its jam. The lemon and orange aromas have been reproduced using pastry flavours, and dried rosebuds for the aroma of rose. The banana aroma, finally, was prepared using a chemical compound named isoamyl acetate, an ester formed by acetic acid and isoamyl alcohol (3-methyl-1-butanol) (Ribéreau-Gayon P., 2017).

All the samples were placed in biodegradable cardboard cups and were covered with cotton pads in order to hide the contents from the view of panelists and avoid that they were influenced during the sensory recognition.

The session took place in the tasting room of the "Consorzio di Tutela dei vini dei Colli Euganei" in Vo' Euganeo (PD, Veneto). Each panelist independently tried to identify the ten aroma samples by pausing between one session of five aromas and the next. At the end of the session each of them expressed what they had identified through the smell of these aromas in the glasses.

The next phase was the tasting of two young Merlots and two young Cabernet Sauvignons, both produced without aging in wood and both representative of the Padua Hills. Thanks to the help of the previous phase of training on aromas and the aid of the brochure with an aroma wheel made available to all the panelists, they were able to identify the representative aromas present in higher concentrations in the two wine types.

Figure 7. Photos of the first training session.

3.4.2 The selection of descriptors

The aromas descriptors included in the sensory evaluation were decided on the basis of what was found during the tasting of the wine samples and through a common vocabulary, 16 most representative descriptors were selected for the Merlots and 19 for the Cabernet Sauvignons.
The selected descriptors were divided into the different senses of sight, smell (including orthonasal and retronasal perception), taste and after-taste.
Vision included evaluating colour intensity for both the Merlot and Cabernet Sauvignon wines.
The olfactory sensations have been divided into fruity, floral, vegetable and other notes. Fruity notes included aromas of red fruits, dark fruits, stone fruits and apple peel. The assessors agreed on the distinction of the descriptors, especially for red and dark fruits. For the Merlot wines, the aromatic descriptors of strawberry, raspberry, cranberry, currant for the red fruits and black cherry, blackberry, blueberry for the dark fruits; for Cabernet Sauvignon wines, however, the aromatic descriptors of strawberry, raspberry, blueberry, currant, red cherry for red fruits and black cherry, blackberry, bilberry, and cassis for the dark fruits were selected. As regards stone fruits, the aromas of cherry and prune were included in both wines. The floral notes included the aroma of violet and rose for both wines, while, for the vegetal notes, aromas of green pepper/tomato leaf were selected for Merlot wines and pepper/tomato leaf and mountain grass for Cabernet Sauvignon wines. Other notes included the malolactic aroma of dairy products, cocoa and spiciness (which includes cloves, black pepper and green pepper) for both Merlot and Cabernet Sauvignon wines but for the latter, aromas of graphite and balsamic were also included; the balsamic aroma intended as notes of eucalyptus and mountain pine.
The other descriptors were the same for both wines and are acidity, sapidity, astringency and bitterness for the taste, and persistency for the after-taste.

3.4.3 The sensory evaluation of the eleven Merlots and Cabernet Sauvignons wines

The sensory evaluation of the Merlot and Cabernet Sauvignon wines was carried out in different sessions, due to the large number of samples to be analyzed.
Evaluation sheets were prepared for both sessions with the sensory descriptors defined in the previous training session (figure 8 and 9).

SIGHT	# ASSESSOR:	MERLOT WINE:
COLOUR	INTENSITY COLOUR	weak — intense
OLFACTORY SENSATION (orthonasal and retronasal perception)		
FRUITY NOTES	RED FRUITS (strawberry, raspberry, cranberry, currant)	Absent — intense
	DARK FRUITS (blackcherry, blackberry, blueberry …)	Absent — intense
	STONE HINTS (cherry, prune)	Absent — intense
	APPLE PEEL	Absent — intense
FLOREAL NOTES	VIOLET	Absent — intense
	ROSE	Absent — intense
VEGETAL NOTES	GREEN PEPPER/ TOMATO LEAF	Absent — intense
OTHER NOTES	DAIRY PRODUCTS (malolactic)	Absent — intense
	COCOA	Absent — intense
	SPICY (cloves, peppers)	Absent — intense
TASTE		
	ACIDITY	Absent — intense
	SAPIDITY (mineral)	Absent — intense
	ASTRINGENCY	Absent — intense
	BITTERNESS	Absent — intense
RETRO-OLFACTORY EXAMINATION (AFTER-TASTE)		
	PERSISTENCY	short — long

Figure 8. Evaluation sheets for sensory analyses of Merlot.

SIGHT	# ASSESSOR:	CABERNET SAUVIGNON WINE:
COLOUR	COLOUR INTENSITY	weak — intense
OLFACTORY SENSATIONS (orthonasal and retronasal perception)		
FRUITY NOTES	RED FRUITS (strawberry, raspberry, blueberry, currant, red cherry)	Absent — intense
	DARK FRUITS (black cherry, blackberry, bilberry, cassis …)	Absent — intense
	STONE FRUITS (cherry, prune)	Absent — intense
	APPLE PEEL	Absent — intense
FLORAL NOTES	VIOLET	Absent — intense
	ROSE	Absent — intense
VEGETAL NOTES	PEPPER / TOMATO LEAF	Absent — intense
	MOUNTAIN GRASS	Absent — intense
OTHER NOTES	DAIRY PRODUCTS (malolactic)	Absent — intense
	COCOA	Absent — intense
	SPICY (cloves, black and green pepper)	Absent — intense
	GRAPHITE	Absent — intense
	BALSAMIC (eucalyptus and mountain pine)	Absent — intense
TASTE		
	ACIDITY	Absent — intense
	SAPIDITY (mineral)	Absent — intense
	ASTRINGENCY	Absent — intense
	BITTERNESS	Absent — intense
RETRO-OLFACTORY EXAMINATION (AFTER-TASTE)		
	PERSISTENCY	short — long

Figure 9. Evaluation sheets for sensory analyses of Cabernet Sauvignon.

For each descriptor a continuous graphic scale was drawn, in which each point indicated an intensity level of the characteristic under examination. For the intensity of the colour the range was from weak to intense; for persistency the range was based on its duration, from short to long; for all other descriptors the range was from the absence of the descriptor to its greatest intensity. In this type of evaluation, the frequent problem is that the judges tend to give scores in the middle range of the scale, and the products may appear more similar to each other due to the reduced breadth of the scale (Pagliarini E., 2021); for this reason, the extreme points were marked to avoid that the judgment appeared flattened.

The wines to be evaluated were randomized, so that they could be distributed to each judge in a different order; this was important to avoid that the panelists could copy each other and be influenced in the evaluation. Each bottle of wine was identified with an anonymous code so as not to influence the judges.

Figure 10. Randomized bottles of wines to be evaluated.

These sensory evaluations were replicated twice for the Merlots (April 19 and May 10, 2023) and twice for the Cabernets (April 26 and May 12, 2023), in order to obtain more representative results. In repeated sessions, the judges were also randomized and placed in different seats, another technique to reduce influences and errors.

The points taken on the continuous graphic scale for each descriptor established by each judge were measured in centimeters using a ruler. All the numbers obtained have been converted to decimal for easier processing.

3.5 The statistical analysis

The data obtained from the analysis were processed by registering the scores in an Excel spreadsheet, and analysed through a two-way Analysis of Variance (ANOVA) model with main effects of samples and assessor and its interaction, using software Panelcheck v 1.4.2.

Mean values of the intensity ratings of each attribute were calculated and illustrated in a spider chart and with the Principal Component Analyses (PCA).

4. Results

4.1 Wine's analytical composition

For all the eleven Merlots and Cabernet Sauvignons, all the analytical parameters and their average values are shown in Tables 2 and 3.

In terms of alcoholic strength, the average values of the two sets of wine are similar (13.65% v/v Merlot vs 13.52% v/v Cabernet Sauvignon), but with a certain intravarietal variability. In particular, for Merlot the range was 12.25-14.50%, a very similar range observed also for the Cabernet Sauvignon 12.30-14.45%. The average value of sugar content was 0.20% w/v for both Merlot and Cabernet Sauvignon wines. The volatile acidity showed values of 0.60 g/l in the Cabernet Sauvignon and 0.55 g/l in Merlot. The total acidity values were slightly higher in Merlot wines (5.04 g/l Merlot vs 4.77 g/l Cabernet Sauvignon) while average values of pH showed very similar values (pH of 3.62 in Merlot vs pH of 3.73 in Cabernet Sauvignon). As regards the total acidity was found intravarietal variability; the range of total acidity was 3.9-6.25 g/l for Merlot and 3.9-5.5 g/l for Cabernet Sauvignon. In terms of total dry extract, which is the sum of the non-volatile solids of a wine such as sugars, non-volatile acids, minerals, phenols, glycerol, glycols, and traces of other substances such as proteins, pectins, and gums the average values were 29 g/l in Merlot and 30.4 g/l in the Cabernet Sauvignon; same small differences between Merlot and Cabernet Sauvignon were observed for the net dry extract, consisting of all the non-volatile substances of the wine net of the reducing sugars, which are considered as potential alcohol (Robinson J., 2014). The average values of total polyphenols and anthocyanins of the two sets of wine were very similar (2252 mg/l Merlot vs 2382 mg/l Cabernet Sauvignon for total polyphenols; 252 mg/l Merlot vs 281 mg/l Cabernet Sauvignon for anthocyanins), but was observed intravarietal variability with a range of total polyphenols of 1500-3075 mg/l in Merlot and 1465-2930 mg/l in Cabernet Sauvignon and a range of anthocyanins content of 137-420 mg/l in Merlot and 170-388 mg/l in Cabernet Sauvignon. For the content of potassium, malic acid, lactic acid, tartaric acid, no intravarietal variability and variability between the two types of wines highlighted. The total SO_2 content presented a slight variability between the two sets of wines (51 mg/l in Cabernet Sauvignon vs 39 mg/l in Merlot) showed intravarietal variability for both the wines, with a range of 30-60 mg/l of SO_2 in Merlot and a range of 30-90 mg/l in Cabernet Sauvignon. For the free SO_2 similar ranges were observed for both the wines.

4.2 Sensory analysis procedure

The selection of the definitive sensory descriptors used in the official analyses was decided through some important considerations derived from the first training session. The group discussed together the descriptors present in the two types of wines tasted; this was the most important step in uniformly understanding the meaning of each descriptor and making sure that each judge meant the same characteristics for each of the sensory descriptors selected.

The red fruits descriptor detected in the Merlot wines showed aromas of strawberry, raspberry, redcurrant and cranberry indicating less ripe fruits as indicators of higher acidity. In Cabernet Sauvignon, on the other hand, the panelists identified aromas of strawberry, raspberry but also blackcurrant, the latter in particular a sign of lower acidity and more ripe fruit, compared to Merlot wines. As far as stone fruits are concerned, aromas of cherry and prune (more or less ripe) were identified in both wines, while the apple peel was revealed by the assessors more in Merlots.

Floral descriptors of rose and violet were found in both the wines during the tasting.

The vegetal descriptors identified and selected were green pepper and tomato leaf for Merlot wines but for the Cabernet Sauvignon wines it was decided to eliminate the adjective “green” for the pepper descriptor, because the vegetal aroma detected was more evolved and ripen than what found in Merlot wines. This underlined again the differences in perceived acidity between the two wines.

The other aromas detected during the tasting were buttery and malty aromas, linked to malolactic fermentation and more evident in Merlot wines, in which there were also some notes of cocoa, typical notes of aging and usually less linked to young wines. In any case, in agreement with the judges it was decided to include the descriptors of cocoa and dairy products for both wines. Additionally, spicy notes such as clove, dried fruit, black or green pepper were also detected and were included as descriptors for both wines. For the Cabernet Sauvignon, during training, other scents were found, indicative of a more complex bouquet. In particular, notes of peppermint, menthol, resin, pinus mugo, and eucalyptus were reported, which were all included as “balsamic” descriptors. Some judges also found woody, leathery, and burnt notes in Cabernet Sauvignon, but they weren’t included because they are usually suboptimal descriptors for a young wine, and were probably considered a fault, because if wines already have these characteristics when young, cannot be suitable for subsequent ageing which is instead necessary for the production of Premium wines. Finally, in the Cabernet Sauvignon wines, some judges identified mineral notes, ethereal sensations potentially linked to the low pH and to a decisive sapidity. These notes were then grouped in the descriptor "graphite".

The retro-olfactory sensations, on the other hand, have been grouped in the persistence descriptor, for both wines, intended as taste-olfactory intensity that remains clearly present (persistent) in the oral cavity for many minutes after swallowing (Lesschaeve & Noble, 2022).
For the taste sensation, the acidity was evaluated in terms of fixed acidity, understood as the total amount of non-volatile organic acids such as tartaric acid, malic acid, lactic acid, citric acid and succinic acid; astringency was considered a tactile sensation perceived in the mouth as dryness, and in the tongue as roughness, due to the action of tannins; bitterness was enhanced by other properties and, like the astringency, was linked to the presence of tannins, but also phenols and polyphenols and was felt in particular on the back of the tongue; sapidity, on the other hand, was linked to the quantity of minerals salts dissolved in the wine (Robinson J., 2014).

4.3 The statistical results with the analysis of variance

After the training sessions and agreement on attributes and their meaning, all wines were submitted to Quantitative Descriptive Analysis by sing the tasting sheets developed (see figures 8 and 9).
Judges evaluated the eleven Merlot and eleven Cabernet Sauvignon wines in 4 tasting sessions, 2 dedicated to the Merlot, and 2 to the Cabernet Sauvignon wines. Data collected were processed, normalized and statistically analyze by 2-way ANOVA, so to evaluate the effect of two different factors on a dependent variable. The aim was to detect the potential presence of statistically significant differences between the average values of sensory characteristics of each Merlot and Cabernet Sauvignon wines analyzed in the two sessions of April and May.
The level of significance was assessed through the p-value, which indicated a probability threshold. If p-value was < 0.05 there was a 5% probability that there were no differences between the variables and it was evaluated as a significant value (*). The p-value < 0.01 indicated the 1% probability of absence differences and it was considered a very significant value (**). Finally, if the p-value was < 0.001, it indicated the 0.1% probability of absence of differences and was a highly significant value (***).
Tables 4 and 5 summarize the results of the ANOVA conducted for Merlot and Cabernet Sauvignon wines.

Table 4. The 2-way ANOVA results of Merlot wines. All values represent the average of 8 assessors, and are expressed on a 10-points scale.

	Colour	Red Fruits	Dark Fruits	Stone Fruit	Apple peel	Violet	Rose
MRB	8,045	3,725	4,764	4,079	0.303	1,155	0.787
PNZ	5,331	4,086	4,192	3,012	0.181	2,019	0.600
SLV	6,039	4,023	5,880	5,729	0.637	1,056	1,206
BRN	4,704	3,148	2,907	3,248	0.139	1,525	1,229
LRG	6,518	5,507	5,419	4,421	0.437	1,600	1,141
BRB	6,103	3,627	3,132	3,942	0.306	1,072	0.817
ALV	7,755	4,060	5,928	5,338	0.687	1,437	0.512
CLN	8,146	3,993	6,597	5,653	0.819	1,840	0.567
CRP	7,042	3,537	3,537	3,706	0.352	1,637	0.637
FRS	6,197	4,324	4,620	4,609	0.454	1,551	0.861
VO	5,639	5,500	4,160	4,435	1,097	2,282	1,083
Produc effect (F value)	16.12	1.83	4.20	3.38	1.47	1.54	0.49
p-values	**0.000**	0.071	**0.000**	**0.001**	0.171	0.142	0.890

Green pepper	Dairy products	Cocoa	Spicy	Acidity	Sapidity	Astringency	Bitterness	Persistency
1,530	0.535	1,405	2,509	3,815	4,211	5,067	1,782	4,632
1,169	0.370	1,000	2,400	4,822	3,602	3,620	1,706	4,757
1,667	0.639	1,750	3,259	4,928	4,076	4,965	1,704	5,211
2,317	0.465	1,086	1,833	4,852	4,007	4,479	1,711	4,426
0.933	0.338	1,248	1,171	4,083	3,282	3,586	1,685	5,076
1,868	0.326	1,086	1,449	4,162	2,630	3,725	1,773	3,481
1,449	0.535	1,148	2,109	4,350	4,241	5,032	2,046	4,884
1,407	0.352	1,792	2,414	4,854	4,618	5,699	2,113	5,854
1,583	1,093	1,118	2,234	4,113	3,984	3,236	1,009	3,671
1,046	0.238	1,141	1,850	4,206	4,539	3,431	2,412	5,012
1,488	0.808	0.681	0.676	3,609	3,787	3,076	1,419	4,998
0.81	0.91	0.97	2.45	1.14	1.99	2.95	1.00	2.82
0.619	0.533	0.474	**0.014**	0.346	**0.047**	**0.004**	0.453	**0.005**

The colour and dark fruits sensory descriptors showed in the table above, showed p-values of 0.000 indicating the highest significant differences of these descriptors between the different Merlot wines analyzed. The p-values of the stone fruits, astringency and persistency descriptors showed values of 0.001, 0.004 and 0.005 respectively, values below the default value of 0.01, indicating very significant differences. The spicy descriptor showed a p-value of 0.014 and the sapidity descriptor a p-value of 0.047, both values lower than 0.05, which meant that the two descriptors showed significant differences between the different Merlots analyzed. For all the other descriptors, which had p-values > 0.05, no statistically significant differences were observed between the Merlot wines of each winery.

Table 5. The 2-way ANOVA results of Cabernet Sauvignon wines. All values represent the average of 8 assessors, and are expressed on a 10-points scale.

	Colour	Red fruits	Dark fruits	Stone fruits	Apple peel	Violet	Rose	Green Pepper	Mountain Grass	Balsamic	Dairy products
MRB	7,877	2,431	3,282	2,806	0.417	0.759	0.412	0.745	0.782	1,641	0.817
PNZ	6,852	3,898	5,250	3,951	0.354	1,282	0.898	1,102	0.891	2,319	0.574
SLV	7,025	4,887	5,065	4,523	0.447	1,074	0.731	2,012	0.806	1,650	0.442
BRN	6,866	3,683	3,641	3,197	0.396	1,301	1,192	1,417	1,442	0.822	0.389
LRG	5,139	4,708	3,421	3,972	0.461	0.926	0.762	1,324	0.567	1,444	1,139
BRB	5,454	3,868	3,382	3,296	0.206	0.588	0.542	1,116	0.449	1,174	0.681
ALV	7,583	4,016	4,648	4,340	0.269	1,324	0.745	1,495	0.875	2,044	0.447
CLN	7,600	3,870	5,785	5,185	0.222	1,185	0.606	1,322	1,127	2,303	0.750
CRP	6,391	3,667	3,593	3,431	0.475	0.808	0.463	1,030	0.762	1,167	0.604
FRS	6,474	3,539	4,843	3,692	0.405	1,410	0.731	1,505	1,262	2,109	0.634
VO	6,319	4,340	3,900	3,377	0.597	1,333	0.937	2,417	1,440	1,887	1,167
Product Effect (F values)	11.50	2.76	2.56	1.82	0.69	1.14	1.01	2.25	1.29	2.70	0.80
p-values	**0.000**	**0.006**	**0.011**	0.073	0.733	0.346	0.447	**0.024**	0.255	**0.007**	0.632

Cocoa	Spicy	Graphite	Acidity	Sapidity	Astringency	Bitterness	Persistency
0.400	1,602	1,711	3,808	3,079	3,725	2,662	4,130
1,472	2,222	0.456	4,185	4,014	4,264	2,639	5,354
0.956	2,440	1,245	4,104	4,275	3,905	2,669	5,366
0.486	1,363	1,602	4,558	3,493	4,634	2,769	4,282
1,743	1,444	0.808	3,438	3,428	2,558	2,271	4,373
1,380	0.782	0.549	3,928	3,407	3,542	2,171	3,722
1,368	1,965	1,903	4,118	4,016	5,169	3,127	5,016
1,299	1,685	0.810	3,701	3,958	3,197	2,586	4,924
0.961	1,345	1,141	3,405	3,417	4,370	2,444	4,410
1,856	2,044	1,472	4,164	4,069	3,352	2,146	4,799
1,356	1,549	1,141	3,787	3,630	3,581	2,266	4,882
1.74	1.55	0.94	1.42	0.98	3.80	1.09	2.65
0.089	0.139	0.504	0.189	0.467	**0.000**	0.380	**0.008**

In the case of Cabernet Sauvignon wines the descriptors that showed the greatest significant differences were colour and astringency with p-value of 0.000. As regards the red fruits, balsamic and persistency descriptors, the respective p-values were 0.006, 0.007 and 0.008, all below the value of 0.01, indicating very significant differences between the Cabernets of the different wineries. The dark fruits and green pepper descriptors represented significant differences between their p-values which were 0.011 and 0.024, respectively. For all the other descriptors, which had p-values > 0.05, no statistically significant differences were observed between the Cabernet Sauvignon wines of each winery.

The data obtained from the sensory analyses, and presented in tables 4 and 5, were represented through spider-plot graphics. The main purpose of this graph was to highlight the level of perceived intensity of all the descriptors of the wines analysed, in order to had a direct comparison between them.

In the graphs there were unstructured axes arranged radially in the plane and starting from the central point: each of them indicated a sensory descriptor; in our spider plots showed in figures 11 and 12, the range of the axes went from intensity values of 0 to 10. The mean intensity value of each descriptor evaluated in the two different sessions by the eight judges was represented by a node on the axis, with a coloured line drawn to connect the data values for each axis, so as to form a polygon with the characteristic shape of a star figure. Thus, the aromatic profiles of the wines were graphically obtained.

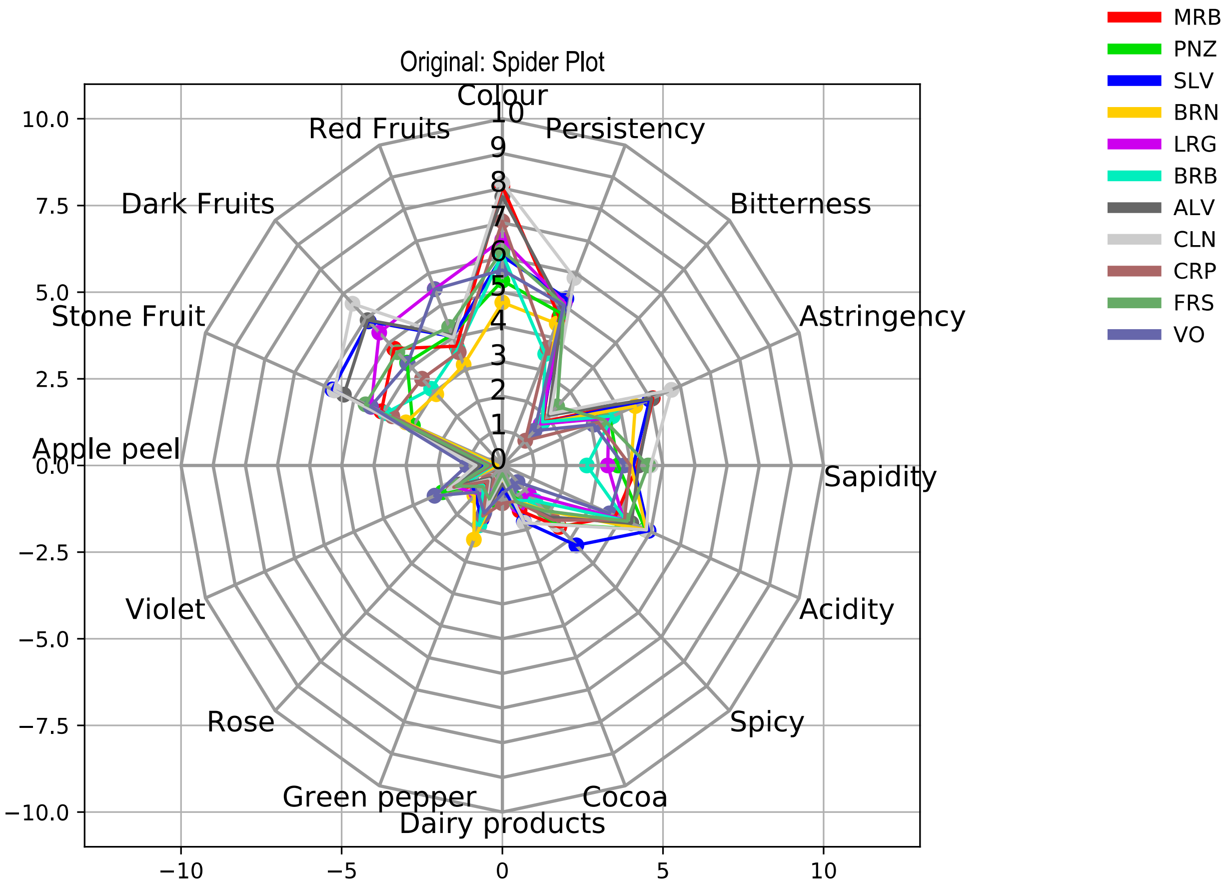

Figure 11. Spider plot with the sensory characteristics of Merlot wines.

In figure 11, it is easy to see the Merlot sensory descriptors representing higher significant differences (p-value < 0.001) due to the higher distances of the nodes in the axes. For example, for dark fruits that showed high significant differences, a greater distance between the nodes of each average value evaluated for each winery can be noted; the opposite was demonstrated in the case of the dairy product descriptor, where the distances between each node was very small, and the nodes were located very close to each other, demonstrating the absence of statistically significant differences (p-value > 0.05) in the Merlots of each winery evaluated in the two sensory sessions, in terms of that descriptor.

Figure 12, below, shown a spider plot of the seven descriptors that showed the highest significant differences in the Merlot wines evaluated, with p-value range between 0.05 and 0.001.

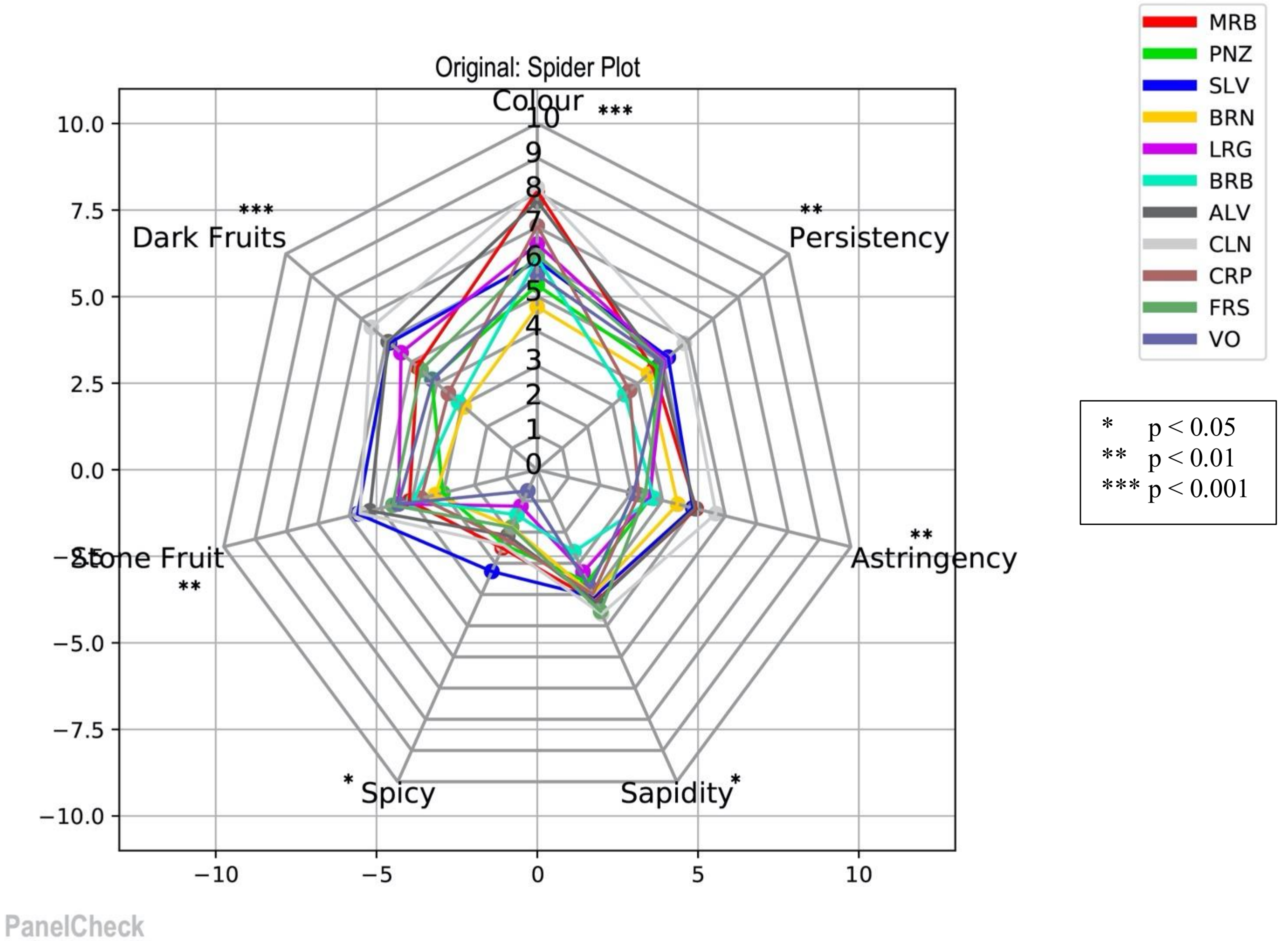

Figure 12. Spider plot with the sensory characteristics with significative statistical differences of Merlot wines.

Looking at figure 12, the colour descriptor showed higher differences between the average value of intensity between each Merlot wine; the highest intensity value was represented by the Merlot wine of the CLN winery, with an average value reported in table 4 of 8.2 followed by the wines of the MRB and ALV wineries, against the wine of the BRN winery which instead showed the lowest intensity of colour with an average value of 4.7, almost half. The Merlot of CLN winery also showed higher intensity values for other descriptors such as dark fruits, stone fruit, sapidity, astringency and persistency, while, the Merlot of BRN still showed lower average intensity values for the dark fruits descriptor (2.9) and for the stone fruit descriptor (3.2), in the latter together with the lowest intensity level of stone fruit descriptor of the PNZ Merlot (3.01). For the spicy and astringency descriptors, the lowest intensity values were represented by the Merlots from the VO' winery with average values of 0.7 and 3.1, respectively. In the spicy descriptor, the highest intensity value was instead represented by the Merlot from the SLV winery with a value of 2.4. Finally, the Merlots of the BRB winery showed lower intensity values of 3.5 for the persistency descriptor and 2.6 for the sapidity descriptor.

The same work was carried out for Cabernet Sauvignon wines in which the main significant differences were highlighted by the colour and the astringency descriptors.

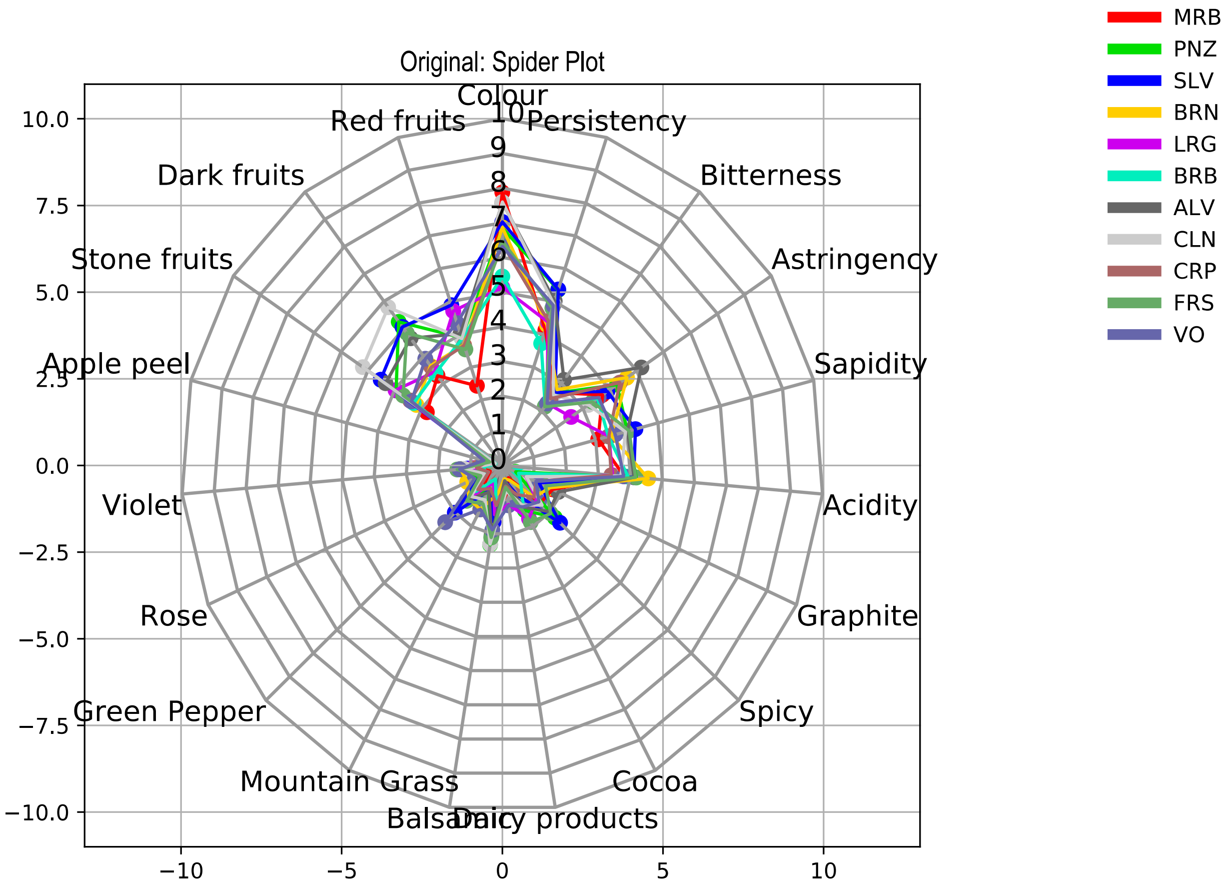

Figure 13. Spider plot with the sensory characteristics of Cabernet Sauvignon wines.

Looking at figure 14, the colour descriptor showed higher differences between the average intensity values of each Cabernet Sauvignon wine; the highest intensity value was represented by the Cabernet Sauvignon wine of the MRB winery, with an average value reported in table 5 of 7.9 followed by the wines of the ALV and CLN wineries, against the wine of the LRG winery which instead showed the lowest colour intensity average value of 5.1. The Cabernet Sauvignon of the SLV winery showed high levels of intensity for many of the descriptors, in particular it showed the maximum intensity in the persistency descriptor with an average value of 5.4 and in the red fruits descriptor with a value of 4.9, followed by the wines of LRG and VO wineries. The Cabernet Sauvignon of MRB winery, instead, obtained the lowest intensity values for the three descriptors of red fruits (2.4), dark fruits (3.3) and green pepper (0.8). As regards the highest intensity levels for the dark fruits and balsamic descriptors, the CLN winery showed the best values with average intensity value of 5.8 and 2.3, respectively. For the balsamic descriptor, the lowest intensity was instead represented by the Cabernet Sauvignon wine from the BRN winery, with a value of 0.8. The highest intensity values for the green pepper and astringency descriptors were highlighted by the Cabernet Sauvignon wine of the ALV winery with values of 1.5 and 5.2, respectively, while for the latter the lowest value was represented by the LRG winery (2.6). For the persistency descriptor, the lowest intensity value was reported by the Cabernet Sauvignon from the BRB winery with an average value of 3.7.

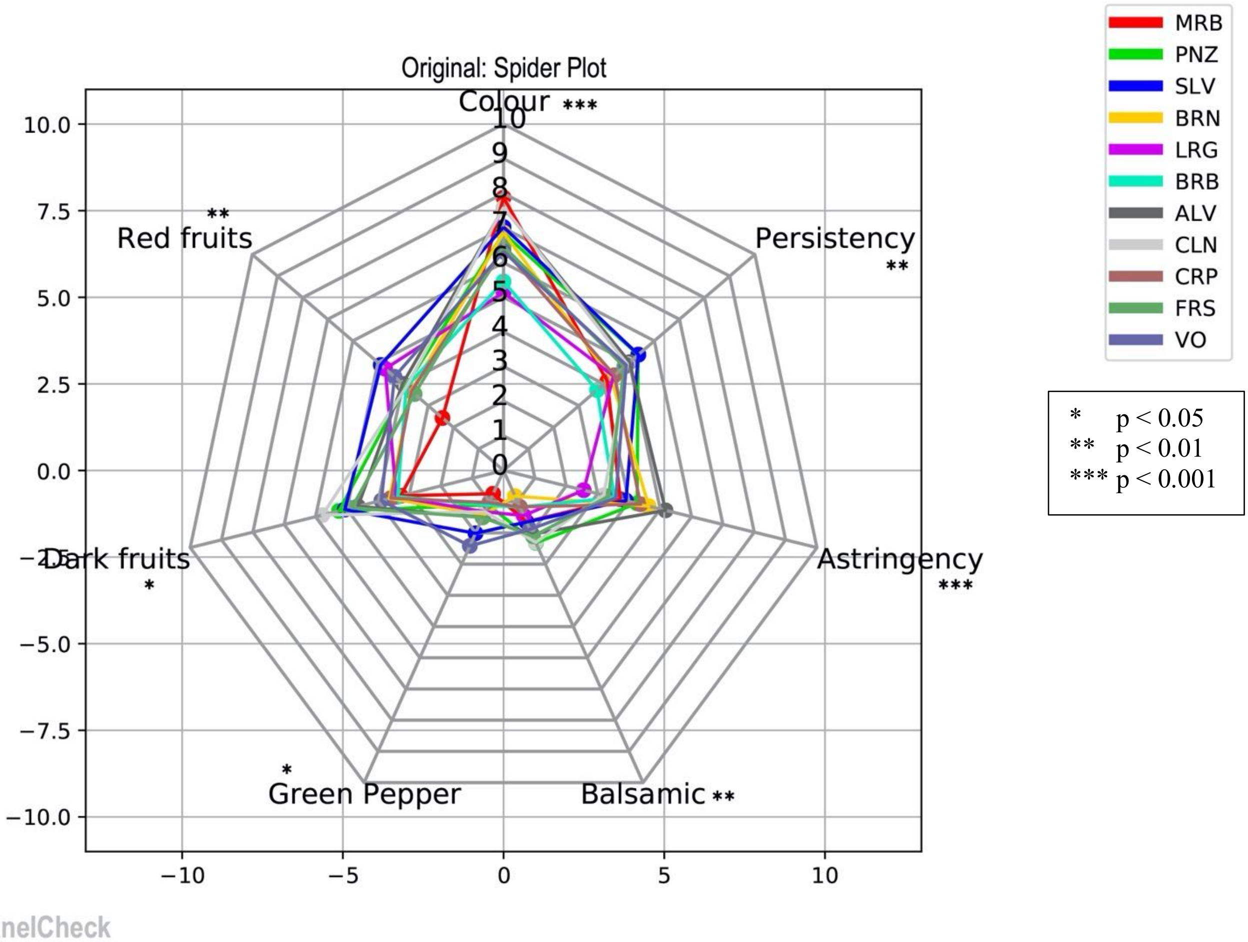

Figure 14. Spider plot with the sensory characteristics with significative statistical differences of Cabernet Sauvignon wines.

An additional statistical method, named Principal Component Analysis (PCA), was employed with the goal of reducing a set of information to its principal components while minimizing the loss of information.

The PCA analysis of the Merlot wines shown in figure 15 showed the two main components examined which respectively described the 52.8% (PC1) and 19.3% (PC2) of the variability of the samples, explaining overall the 72.1% of the variance in the sensory profile descriptions of the eleven Merlot wines.

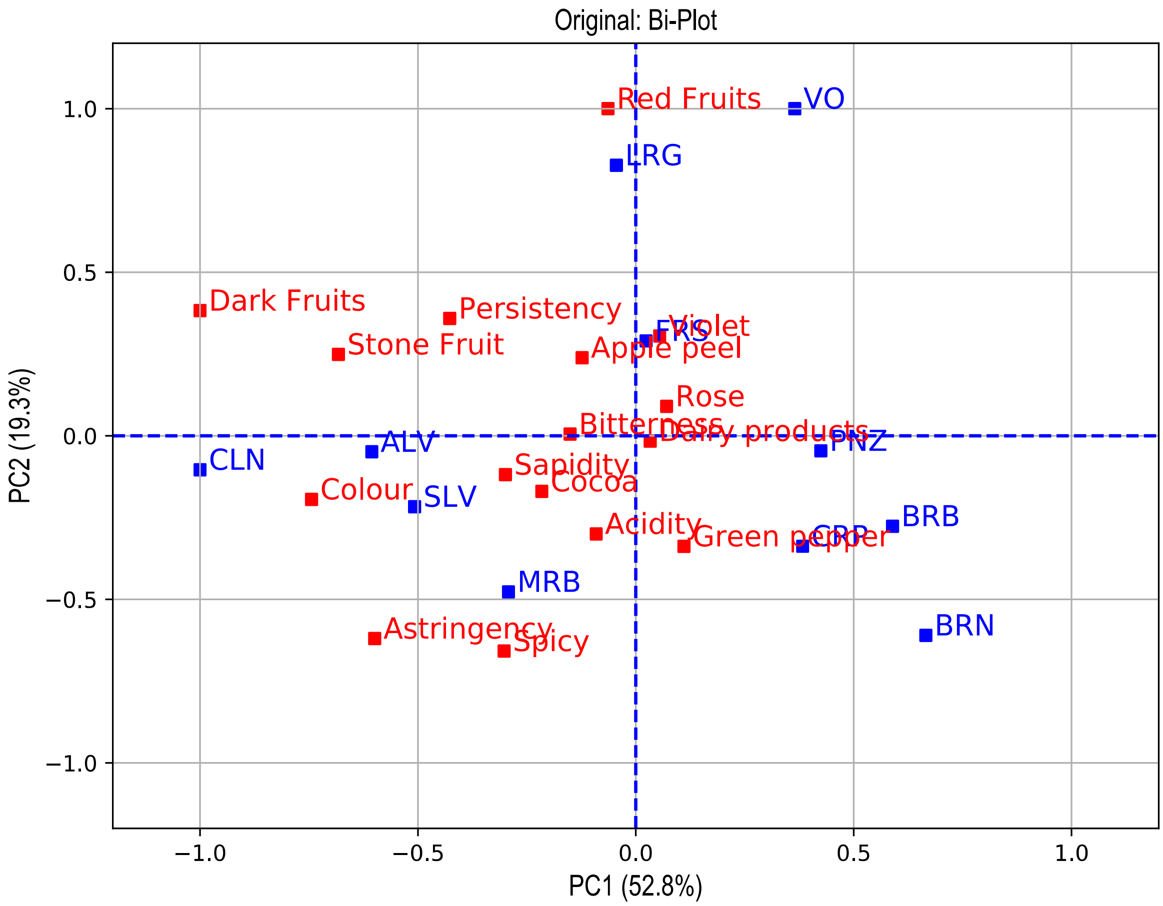

Figure 15. PCA relatives to 16 sensory descriptors valued on 11 different Merlot wines. Projection of the cases on the factorial plane of the two principal components PC1 and PC2.

The Merlot samples, represented by the winery code, were showed in blue and each point represented the average value of the two replicas, while the sensory descriptors were represented in red. The axis of each principal component was divisible by a positive semi-axis (with coordinates ranging from 0 to +1) and a negative semi-axis (with coordinates ranging from 0 to −1). The point of intersection of the axes of the Cartesian plane represented the coordinates 0.0, called "center of gravity". Descriptors closed to zero didn't explain much of the sensory variance between samples and they varied independently of each other; the descriptors considered were bitterness, dairy products, rose, green pepper, cocoa.

The position of a variable in the diagram depends on its weights on the two components represented in the diagram and the higher these are, the more the variable will move away from the center of gravity, such as for the descriptors colour, astringency, spicy, dark fruits, stone fruits, persistency which were the more discriminant. For example, the Merlot samples from the MRB, SLV, ALV and CLN wineries were positioned in the same Cartesian side of the colour, cocoa, spicy, sapidity and

astringency descriptors, based on the values of their higher intensity perception demonstrated through the statistical analyses. The same was shown for the Merlot wines of the VO and LRG wineries which positioned themselves close to the red fruit descriptor, which indicated their high correlation; through table 4, it is easy to verify that these two Merlot wines revealed the highest intensity values of perception for the red fruits descriptor. Another correlation was that between the green pepper descriptor and the Merlot wines produced by the BRB, CRP and BRN wineries, wines that presented higher intensity values of this descriptor perceived by the assessors.
The same analysis was reproduced also for the Cabernet Sauvignon wines as in the figure 16.

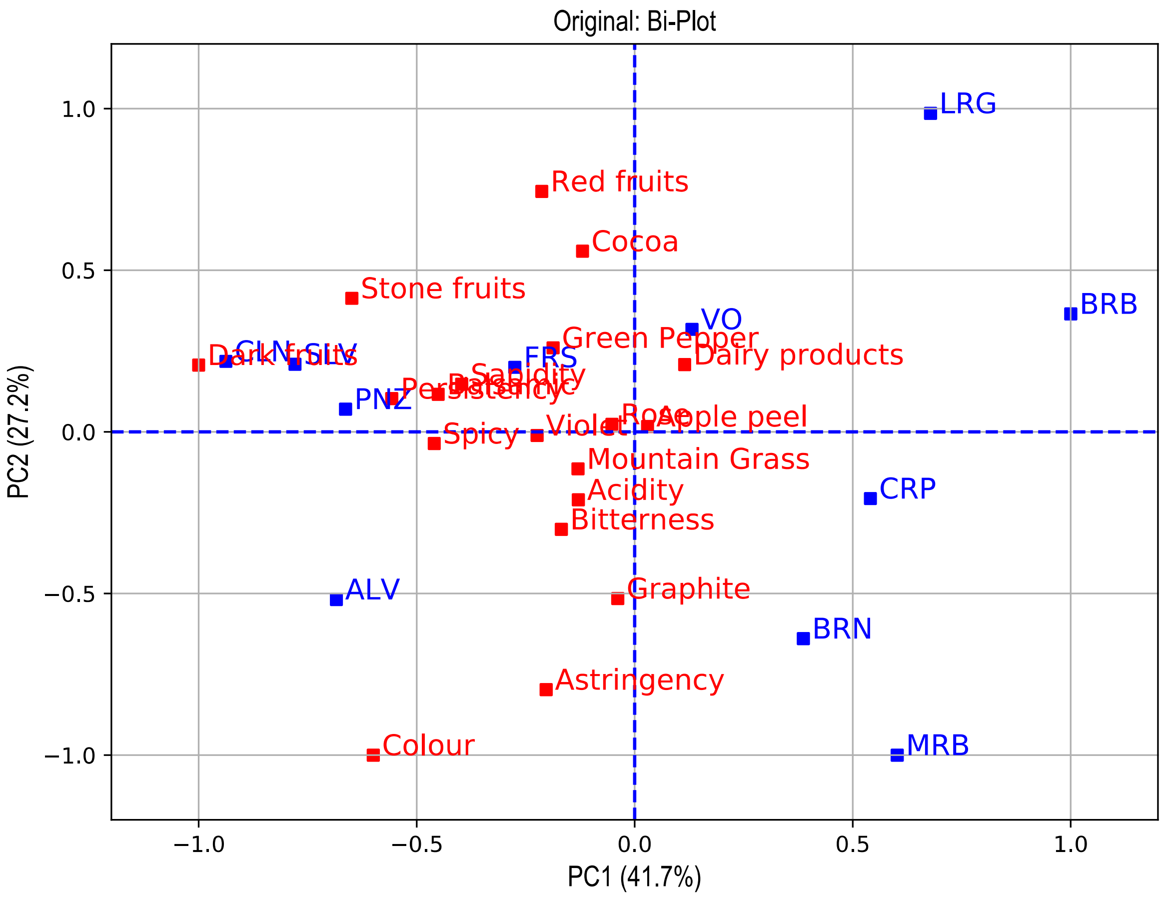

Figure 16. PCA relatives to 19 sensory descriptors valued on 11 different Cabernet Sauvignon wines. Projection of the cases on the factorial plane of the two principal components PC1 and PC2.

The PCA analysis of the Cabernet Sauvignon wines shown in figure 16 highlighted the two main components examined which respectively described the 41.7% (PC1) and 27.2% (PC2) of the variability of the samples, explaining overall the 68.9% of the variance in the sensory profile descriptions of the eleven Cabernet Sauvignon wines. Also in this case, the most discriminant variables that weighed the most on the two components, were placed away from the centre of gravity and were the descriptors of colour, astringency, red fruits, dark fruits, stone fruits, balsamic, persistency. In contrast, the rose, the violet, the apple peel descriptors were close to zero and didn't explain much of the sensory variance between samples. As regards the correlations, the Cabernets produced by the CLN, SLV, PNZ wineries were positioned close to the dark fruits descriptor, highlighting their greater intensity value perceived for this descriptor, equally visible in table 5. The wine from the ALV winery was located in the same cartesian side of the colour, astringency and bitterness descriptors for which it represented the higher intensity values evaluated by the judges. Another example was the graphic proximity between the Cabernet Sauvignon wine from the VO winery and the descriptors of dairy products, for which it represented the highest intensity value compared to the other ten Cabernets. BRB and LRG samples were distant because they separated from each other not by a specific descriptor but by several descriptors.

5. Discussion

5.1 Colour, astringency, persistency and sapidity

The analysis of Merlot and Cabernet Sauvignon wines highlighted statistically significant differences in some sensory descriptors among the eleven samples.

For both Merlot and Cabernet Sauvignon wines the descriptor that highlighted highest significant different values was the colour intensity with p-values < 0.001. This descriptor is mostly related to the content of anthocyanins which depends on the variety of the grape, the acidity, the SO_2 content, the ageing of the wine, the climate and territory conditions. Some varieties have skins richer of tannins and give deep and impenetrable red colour to the wines, as for Merlot and Cabernet Sauvignon grapes which are among the darker grape vines (He et al., 2012). The concentration of these pigments decreases during the wine ageing due to their polymerization with other chemical substances which forms other complex pigments that lead to a change in color from purplish red in young wines (as in the wines considered in this study), to brick red in aged wines. The presence of anthocyanins is also influenced by the climate and the territory conformation; usually, warmer climates in areas with greater exposure to the sun allow the synthesis of sugars and polyphenols, in which these coloring pigments are included (He et al., 2012).

The results of the sensory analysis of the eleven Merlot wines showed the colour of higher intensity in the wine produced by CLN winery, followed by the ones produced by MRB and ALV winery. The correlation between color intensity and anthocyanin content of these wines was verified trough the analytical parameters listed in table 2, in which, these three Merlots reported the highest anthocyanin levels; in detail, the Merlot from the CLN winery had the highest content of 420 mg/l of anthocyanins, followed by the 353 mg/l of the Merlot from the MRB winery and the 316 mg/l in the Merlot of ALV winery (R2 = 0.68). The vineyards of production of these three Merlots were located in hills and foothills, favorable positions for exposure to the sun. In detail, the location of the vineyards owned by the CLN and MRB wineries is to the north-east, where the climate allowed good insolation on the morning, while the vineyards for the production of the Merlot owned by the ALV winery, were located in the central area characterized from higher altitudes which guaranteed higher exposure. Thus, climate and anthocyanin production could potentially be related. Further considerations can be made on the characteristics of the soil which can influence the wine features. The synthesis of sugars, polyphenols, and mineral substances is higher in not too fertile calcareous-clayey soils with a fine and not too compact texture and characterized by medium-small porosity capable of retaining the right amount of water and mineral salts, important for the vine to guarantee the concentration of the substances which will be found in the must (Van Leeuwen, 2010). The Merlot vines of the MRB and ALV wineries were characterized by calcareous-clayey marls, a fact that could result in the production of grapes richer in pigments. The Merlot vine produced by the CLN winery, instead, was cultivated in trachytic and rhyolitic soils with a medium-coarse texture, medium-high sugar content, good acid balance and richness in nutrients, that finally give wine complexity (Disciplinare di Produzione dei vini DOC dei Colli Euganei, 2014).

The results of the sensory analyses of the eleven Cabernet Sauvignon wines didn't show the same correlations as the Merlot wines ($R2 = 0.48$). In this case, the highest colour intensity values detected during the sensory analyses were found in the same wines from the MRB, CLN and ALV wineries; in this case, no correlations were observed between the evaluation of the colour intensity and the anthocyanin content, with the only exception of the Cabernet Sauvignon produced by the CLN winery; this one had an anthocyanin content of 388 mg/l (shown in table 3). For this wine, was also observed as for the Merlots, a potential relation between the highest anthocyanin content and the great exposure to the sun due to the position of its production vineyards on the eastern hill area of "Colli Euganei", characterized by good insolation especially in the morning hours. With regards to the soils, these vines were located in calcareous-clayey marl as for the Merlots of the MRB and ALV wineries. In general, the judges rated the colour of the Cabernet Sauvignon wines as more uniform and slightly more colourful than that of the Merlot wines.

The other descriptor that highlighted more significant differences for both wines analyzed was the astringency, in particular for the Cabernet Sauvignons in which the highest variability was highlighted with p-values < 0.001.

Astringency is a tactile sensation perceived in the mouth as a sensation of dryness, roughening and puckering (Canon et al., 2022) and which takes time to fully develop (Fontoin et al., 2008). The substances responsible for this stimulus are the tannins, a group of polyphenols present in the skins, stalks and pips of grapes, extracted during the maceration process in the alcoholic fermentation. Their molecular chains are built with catechins, substances capable of condensing the proteins present in saliva giving the sensation of astringency. The different characteristics of saliva in each person underlines how the perception of these substances can be so different from individual to individual (Canon et al., 2022).

In Merlot wines the highest average values for astringency were found in the wines of CLN, MRB, ALV, and SLV wineries. These sensory results can be explained by the corresponding quantity of polyphenols reported in the chemical analyses (table 2) which showed a content of 3075 mg/l of polyphenols in the Merlot wine of the CLN winery, followed by as many high quantities in the wines of MRB, ALV and SLV wineries, confirming the correspondence with sensory analysis ($R2 = 0.66$). As far as Cabernet Sauvignon wines are concerned, the wine of the BRN winery with a polyphenol content of 2930 mg/l and by the wine of the ALV winery, with a content of 2800 mg/l showed the higher intensity values for the astringency descriptor but, in this case the correlation between astringency and total polyphenols is lower than the one showed for Merlot wines ($R2 = 0.46$).

Temperatures and exposure to the sun, during grape ripening, can influence the biosynthesis of these substances (Fontoin et al., 2008) but in this case-study, all the Merlot and Cabernet Sauvignon vineyards that had a higher intensity of astringency perception were located in different areas of the Padua Hills characterized by different exposure and microclimates, not confirming the potential correlation between tannins and terroir.

The perception of astringency is also related to the perception of bitterness, (Soares et al.,2020) and this emerged from sensory analyses, where the wines considered more astringent by the panelists were also evaluated as the most bitter.

In some wines, such as the Cabernet Sauvignon from the SLV winery, many reactive tannins were found which in the young wine were considered positive, useful for the subsequent obtaining of an important Premium red wine. This is because the tannins polymerize and precipitate during the ageing of the wine, only subsequently reaching an equilibrium with the other components, contributing to lowering the strong perception of astringency which instead characterized them in their youth and creating a greater roundness of the same (Preez et al., 2022).

Another descriptor that showed high variability (p-values < 0.01) for its duration of perception in both Merlot and Cabernet Sauvignon wines was the persistency. It indicates the retro-olfactory sensations of the wine which occur at the end of the tasting due to the fact that in contact with our mouth it undergoes an increase in temperature which determines the volatility of the various molecules. It is evaluated as the length of time in which taste-olfactory sensations remain in the oral and retronasal cavity (Muñoz-González et al., 2019); it increases if the wine has a good structure, which means balance between the volatility of the aromatic substances, a good content of tannins, a good and balanced acidity. The sensory analyses of the Merlots showed the highest length of persistency for the wines produced by the CLN and SLV wineries, followed by equally high values for the wines from the LRG and FRS wineries. As for Cabernet Sauvignons, the longest persistency was shown by the wines of SLV and PNZ wineries, followed by those produced by ALV and CLN wineries. If we look at the analytical parameters in Table 2, most of these wines were the ones that had the highest content of polyphenols, which could have also influenced the sensory evaluation on this descriptor by expressing a potential relationship.

The sapidity descriptor, unlike the descriptors previously mentioned, highlighted high significant values of different intensity only for some Merlot wines; in detail, the highest perception was found in the Merlot produced by the CLN winery, followed by other higher values in the wines of the FRS, ALV and MRB wineries. This descriptor, also referred to as “minerality”, can be considered important in wines because it is often associated with the concept of terroir (Zaldívar Santamaría et al., 2019); in particular it is linked to the chemical composition of the soil in which the major elements are found, such as calcium, magnesium, potassium, sodium, iron, etc. (Zaldívar Santamaría et al., 2019). In other previous studies, these elements have been found abundant in wines and have been considered important for their geographical classification (Zaldívar Santamaría et al., 2019). The Merlot vineyards that produced the wine in which the highest perception of this descriptor was detected during the sensory analyses were located in soils made up of trachyte and quartz trachyte, igneous rocks very rich of silica but also containing sodium, calcium, potassium, iron and magnesium, indicating a potential relationship between perception of minerality and soil constituents. Usually, the sapidity descriptor, is more associated to dry white wines with a positive correlation with acidity (Parr et al., 2018); in red wines, on the contrary, from various previous studies, it emerged that this descriptor was positive correlated in relation to the alcohol content, the concentration of tannins and the persistence in the aftertaste (Zaldívar Santamaría et al., 2019). Indeed, the wines with the highest perception of sapidity from the CLN winery, showed high alcoholic strength and highest content of polyphenols (shown in table 2) and the highest value of persistency perception (shown in table 4) evaluated during sensory analyses.

5.2 Aromas

The aromatic composition of a wine derives from the nature of the varietal compounds which determine its expression in specific soil and climatic conditions (Ribéreau-Gayon P., 2017). The varietal aroma includes several compounds such as terpenes, methoxypyrazines, and norisoprenoid derivatives.

Terpenes are a large family of compounds, in which the odour precursors are linked to monoterpenes and sesquiterpenes formed respectively by two/three isoprene units (Ribéreau-Gayon P., 2017). Monoterpenes are formed by ten atoms of carbons and in some varieties they can be found as free volatile compounds, but usually they are present in much higher concentrations in the form of non-odorant precursors linked to sugar molecules (Ruiz et al., 2019); the hydrolysis of the glycoside precursor can be carried out with enzymatic hydrolysis by β-glucosidases enzymes or with the metabolic activities of yeasts during the alcoholic fermentation, which lead to the release of the volatile aromatic compound (Ruiz et al., 2019). These terpenes can be used to identify grape varieties; in Cabernet Sauvignon and Merlot varieties the concentration of these molecules is usually below the olfactory perception threshold and does not have a significant influence on the overall aroma, but some differences in the intensity of these aromas were found in our sensory analysis, albeit with low significance.

Notes of balsamic aromas derived from monoterpene molecules were detected in the Cabernet Sauvignon wines analyzed. This descriptor was understood as notes of eucalyptus and mountain pine, varietal markers that impart freshness and vitality to the overall aroma of Cabernet Sauvignon wines (Ruiz et al., 2019). The most significant values of balsamic intensity were detected in the Cabernets of the PNZ and CLN wineries during sensory evaluation.

In some Merlot wines, on the other hand, notes of black pepper were perceived by the panelists, in particular for the Merlot produced by SLV winery which showed higher values than the other wines. This primary aroma is given by rotundone, a sesquiterpene composed of fifteen carbon atoms which manifests the "peppery" character even at low concentrations, due to its low sensory threshold of 16 ng/l in red wines (Scarlett et al., 2014). It is able to confer in itself a characteristic aroma, an exceptional case in wine, since in most cases the varietal aroma is associated with the relative concentration of various volatile compounds (Ferrarini et al., 2015). This aroma has been identified in several wine cultivars where the rotundone molecule is located in the skin and in the exocarp of the berry and reaches the highest concentration values during the late ripening of the grape (Geffroy et al., 2014). The presence of this molecule is also related to the climate, environmental conditions and viticultural-oenological practices; some previous studies have established that meso-climates with cooler temperatures and possibly rainfall or soil water availability are key factors influencing rotundone development (Zhang et al., 2015), but the winemaking process may also increase its content, because a part of its concentration goes directly to the must and to increase this extraction it is sufficient to carry out a more intense maceration. On the contrary, through filtrations, there is a loss of the molecule (Ferrarini et al., 2015). The aroma of black pepper perceived in the Merlot from the SLV winery can be considered a positive descriptor to differentiate the wine with a characteristic note; its detection is probably related to a greater presence of rotundone which could derive both from the environmental characteristics to which the vineyards are subjected, given the distance from the vineyards of the other wineries whose wines have not shown these aromatic notes, or from the vinification in case a more intense maceration has been carried out.

Another varietal aroma is green pepper, detected by sensory analyses with small but significant differences between Cabernet Sauvignon wines. The highest intensity values were found in the

Cabernet Sauvignons of the VO and SLV wineries. This varietal aroma is related to methoxypyrazines (in particular to 3-Isobutyl-2-methoxypyrazine), nitrogenous heterocyclic compounds deriving from the metabolism of amino acids present in the grape skins and seeds (Ribéreau-Gayon P., 2017). They are powerful odorants with a very low sensory threshold of 1-2 ng/l (Ruiz et al., 2019) and in Merlot, but especially in Cabernet Sauvignon varieties, they usually exceed the perception threshold, representing a negative qualitative trait for these red wines, while, in some white varieties (e.g. Sauvignon Blanc) they are considered appropriate as they add complexity to the product (Ribéreau-Gayon P., 2017). Traditional oenological techniques are unable to modify the content of these substances and, therefore, they can become very stable during the maturation of the wine, influencing its final aroma (Ribéreau-Gayon P., 2017).

The other aromas which characterized the bouquet of red wines are of fermentative origin and are linked to esters, organic compounds derived from the reaction of an alcoholic function with an acid function with the remotion of a molecule of water (Ribéreau-Gayon P., 2017). The fruity aroma is associated to these compounds and in red wines it is particularly important. The type of soils, the climate, the agronomic practices and the winemaking process are big source of variability that lead to a non detailed determination of which specific factors influence this class of molecules. However, some differences between different wineries have been found. As regard the Merlot wines analyzed were detected highly significant values (p-values < 0.001) for dark fruits descriptor, and high significant value (p-values < 0.05) for stone fruit descriptor; in the Cabernet Sauvignon wines, on the other hand, were detected very significant values (p-values < 0.01) for red fruits descriptor and high significant value (p-values < 0.05) for dark fruits.

The Merlot wines which showed higher intensity value for the dark fruits descriptors were the wines produced in CLN winery at first, followed by the Merlots produced in ALV and SLV wineries and the same wines showed higher intensity values also for the stone fruits descriptor. In these three wines the pedoclimatic conditions were different while unknown are the techniques applied during the winemaking process. It is possible to hypothesize that the choice made by the winemaker in order to obtain particular flavour wines has been direct to a particular strain of yeast that lead to a higher production of esters (Ribéreau-Gayon P., 2017).

In the case of Cabernet Sauvignon, no particular differences were detected between the two descriptors. However, the higher intensity values for red fruits descriptor were found in the wines of the SLV and LRG wineries, while the sensory evaluation of dark fruits descriptors showed high intensity differences in the wines produced by the CLN and PNZ wineries.

6. Conclusion

This thesis work has highlighted some distinctive sensory characteristics of Merlot and Cabernet Sauvignon wines from the “Colli Euganei” area, and this are functional to the identification of practices and techniques, both in vineyards and in wineries, suitable to improve the quality of these wines “towards excellence”.

The most important qualitative characteristics perceived during the sensory analyses by the expert panelists showed the results of the viticultural and oenological techniques applied in the production of these two types of wine. On the other hand, the variability obtained through the sensory descriptors represented the significant differences imprinted by the terroir.

The terroir includes all the characteristics related to the territory, and even if the “Colli Euganei” are represented by a single area, they have shown some important differences between climates, altitudes, sun exposure, soil types and others, giving rise to various sub-areas that have their microclimatic and pedoclimatic features. The different location of each single vineyard for the eleven Merlot and Cabernet Sauvignon wines, has highlighted different qualitative properties which have given a personal identity to each wine. The different content of tannins, the acidity values, the colour intensity, the perceived aromas and all other sensory descriptors evaluated by the judges were influenced by the different location of the vineyards through the different climates and the soil composition, thus conferring different qualities; for example, some wines were characterized by a greater quantity of positive descriptors which resulted in a higher perception of quality, compared to other wines which were instead perceived as more flat and less interesting for a subsequent production of high quality wines suitable for ageing.

A key aspect to consider is that the wines analyzed were all young wines and without barrel ageing. For this reason, it was important to evaluate them on the basis of the sensory characteristics typical of young wines, thus noting which wines were more inclined to develop superior qualitative characteristics to become Premium wines after ageing. For some of the wines that, at the moment of the sensory evaluation, were considered ready to deink, the possibility to undergo barrel ageing was discarded. Consequently, it will be necessary to identify the source of the problems in order to solve them, specially by looking at the viticultural aspects as the winemaking of this sample set was standardized.

The importance of getting a Premium wine is related to the concept of quality that nowadays is very important for the market. The ability to be able to express the high quality of a product to the consumer leads to the possibility of being able to sell it at higher price. This concept is linked to the production of the product but also to its territory of origin that must be valorized.

The “Colli Euganei” territory is mostly known for the production of types of wine other than Merlot and Cabernet Sauvignon. However, the terroir of this region is considered highly suitable for the production of Premium red wines. Indeed, a few important producers from this area are already producing internationally recognized Premium red wines. However, a collective approach like the one adopted by this project has the potential to raise the general quality of Premium red wines of the region, a fact that is expected to benefit the reputation of the region as an important producer of this style of wines. This, in turn, is expected to benefit the producers that, via this increased reputation and recognition, should be able to sell their wines at a higher price point.

For this reason, it would be important and interesting to try to enhance the overall quality of these two wines first. The key actions that are needed to reach this ambitious goal are to fine tune the viticultural conditions as well as using enological techniques that respect the territory and the concept of quality, so to be able to produce wines different sensorial characteristics consistent with those of Premium quality red wines.

The typical and common characteristics of these cultivars combined with the personal identity of each wine obtained thanks to the different characteristics of the terroir suited to oenology, could thus allow the production of Premium Merlot and Cabernet Sauvignon wines in the “Colli Euganei” area.

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