



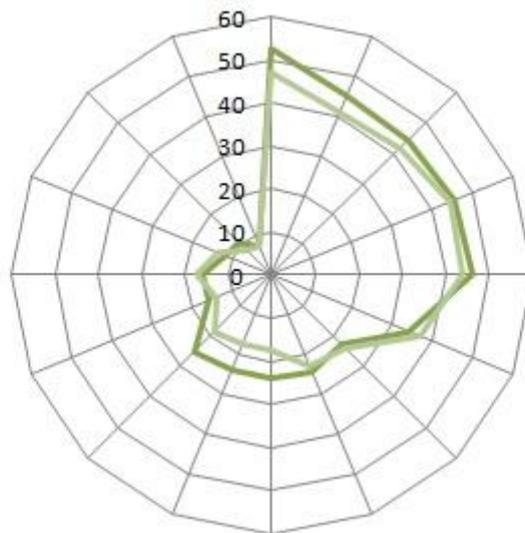
Sveriges lantbruksuniversitet  
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# Sensory profiling of Swedish white wines and a contextual analysis of Swedish viticulture

Sensorisk profilering av svenska vita viner och en omvärldsanalys av svensk vinodling

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## Abstract

The aim of the study is twofold, to generate a sensory profile of Swedish wine today and to investigate the opinion of both wine producers and wine experts on viticulture in Sweden and wine from grapes grown in Sweden, achieved through a contextual analysis comprising a literature study and interviews with wine producers in Sweden and Denmark and wine experts from Sweden and Germany, and a sensory analysis at the company *Ipsos*. ‘Mixed methods’ was the chosen research strategy as the semi-structured interviews gave qualitative results and the sensory analysis would give quantitative results displayed as spider charts.

There is a lack of studies investigating how the Swedish wine is perceived by consumers and consumers might be unaware that the Swedish wine, established through ‘trial and error’, is increasing in quality every season, creating a need to display the sensory profile of Swedish wine to strengthening the perception of Swedish white wine.

This study shows that the Swedish white wine today is a wine with a fresh, citrusy and flowery aroma and a fresh, citrusy and green apple taste, however, a sensory analysis cannot show if the attributes are those that are desired by the customer, a consumer test is necessary to conclude that. Trends point towards locally produced products, one reason why Swedish wine has great potential, yet the future needs to be secured through job opportunities and education. Creating an approval system for Swedish wine is suggested as a future improvement, it is a common procedure in most wine regions. It is a good opportunity for Swedish wine producers as the wine sold at *Systembolaget* does not go through blind tests. Microclimate is of great importance for locations of vineyards in Sweden and GDD (growing degree days) gives a more fair result for sites in Sweden than LTI (latitude temperature index).

**Keywords:** Swedish wine, Nordic wine, sensory analysis, microclimate, wine tourism, Solaris, cool climate, cold climate, viticulture, contextual analysis

## Sammanfattning

Syftet med studien är tvåfaldig, att framställa en sensorisk profil av dagen svenska vita viner och att undersöka åsikter om svensk vinodling och vin från svenska druvor hos både vinproducenter och vinexperter, genom en omvärldsanalys med litteraturstudie och intervjuer med vinproducenter i Sverige och Danmark och vinexperter från Sverige och Tyskland samt en sensorisk analys genomförd av företaget *Ipsos*. Metodkombination valdes som forskningsstrategi då de semistrukturerade intervjuerna skulle ge kvalitativa resultat och den sensoriska analysen skulle ge kvantitativa resultat i form av spindel diagram.

Det är brist på studier som undersöker hur det svenska vinet upplevs av konsumenter och konsumenter kanske är ovetandes om att kvaliteten hos det svenska vinet, som har skapats genom 'trial and error', blir bättre och bättre för varje säsong, vilket skapar ett behov av att visa den sensoriska profilen av svenskt vin för att kunna stärka uppfattningen av svenskt vin.

Studien visar att dagens svenska vita vin är ett vin med en frisk, citrus och blommig doft och en frisk, citrus och gröna äpple smak. Men den sensoriska analysen kan inte visa om de attributen är de som är önskade av en konsument, det krävs ett konsumenttest för att kunna visa det. Det finns stor potential för svenskt vin, inte minst på grund av trenden med lokalt producerade produkter, men framtiden måste då säkras genom att skapa jobbmöjligheter och utbildning. En framtida förbättring av den svenska vinsektorn vore att skapa ett system som godkänner vinerna, en vanlig procedur i många vinländer. Det är ett bra tillfälle för svenska vinproducenter eftersom det svenska vinet som säljs på *Systembolaget* inte genomgår blindtester. Mikroklimatet är en viktig aspekt för att etablera en vinodling i Sverige och GDD (growing degree days) ger mer rättvisa resultat för platser i Sverige än LTI (latitude temperature index).

**Nyckelord:** svenskt vin, nordiskt vin, sensorisk analys, mikroklimat, winturism, Solaris, svalt klimat, kallt klimat, vinodling, omvärldsanalys

## **Abbreviations**

°Brix - an indirect (specific gravity) measure of the total soluble solids in grape juice or wine; typically sugar content in juice and (by adjustment to alcohol content) in wine. Alternative units are Balling, Baumé and Oeschle (Jackson, 2008).

CCOVI – Cool Climate Oenology and Viticulture Institute at Brock University

DDC – Celsius degree days

GDD – Growing degree days

GIS - Geographical Information Systems

Ha – hectare

HI – Huglin index

LTI – latitude temperature index

MTWM – mean temperature of the warmest month

VQA – Vintner’s Quality Alliance

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# 1 Introduction

*Grape growing for vinification is established throughout a smaller acreage of Sweden and the acreage is increasing every year. Due to the fact that Swedish viticulture is young there are several gaps in knowledge both in the production of grapes and the vinification process. A general overview of the thesis is given in this chapter. The background and the problem are explained together with the aim and limitations and the outline of the thesis is presented.*

*The purpose of a contextual analysis is to identify the most important trends, events and actors affecting the activity. A contextual analysis is a systematic process to survey and analyze external information and find strategic solutions according to them. The analysis is divided into three steps; gathering of information and mapping what is going on, analyzing what is going on and assess what that will mean for the future (Genf and Laurent, 2008). This contextual analysis contains a literature study and interviews with wine producers in Sweden and Denmark and wine experts.*

## 1.1 Background

*Livsmedelsverket (Livsmedelsverket, 2014) has 25 Swedish wineries registered and the association Svenska Vinodlare has 47 vineyards as members (Svenska Vinodlare, 2014a). The association Svenska Vinodlare was founded in 2001 and exists to create cooperation between winegrowers and to exchange experiences about growing grapes and vinification. Members are both hobby growers and larger scale growers. It was estimated in 2010 that in Sweden vines are grown on 40 ha and the vineyards are mostly located in Skåne, on the islands Öland and Gotland where the most favourable climates is found. About two thirds of about 250 growers are located in Skåne (Systembolaget, 2010). The report by Vinlandet Sverige (2013) served as background material for this study.*

There are difficulties finding definitions on what a cool climate is and what a cold climate is within viticulture and where Sweden belongs. Throughout the study attempts are made to describe that southern Sweden seems to be in between a cool and a cold climate.

Gustafsson and Mårtensson (2005) concluded that there are good opportunities to establish a wine industry in Scandinavia judging from the example of Canada, where despite the harsh climate including spring frost, short summers and cool winters, the established wine industry is promising and flourishing. Many Scandinavian locations have a poor macroclimate but

have a topographical complexity offering mesoclimates suitable for viticulture. Furthermore it is stated that markets forces and consumer tastes should dictate the most profitable varieties to cultivate, and much attention should be given to the quality of the wine produced.

There is a great potential of producing quality wine in Sweden. However, unlike the traditional wine countries there is no history of winegrowing in Sweden and therefore no tradition and the winegrowers have started from the beginning. There is a need to fill the gaps in knowledge existing in order to achieve the quality potential of Swedish wine.

## **1.2 Problem**

There is a lack of studies investigating how the Swedish wine is perceived by consumers. For this thesis people with experience of tasting Nordic wine were contacted and interviewed to get an external view upon the situation of Swedish wine and also Swedish viticulture. A comparison between opinions of wine producers and people with experience of having been in contact with Nordic wine from several producers for several years will be provided. Wine producers were also interviewed in order to compare the opinions of the two groups.

Since wine from grapes produced in Sweden is relatively new and mostly the producers have had a 'trial and error' approach, the quality of wine therefore gets better and better every year, usually with noticeable differences between the years. A consumer which has tried a Nordic wine once and had a bad experience might be reluctant to purchasing another bottle irrelevant of the wine style since the high prices will not encourage the thought that the product might be fun to try again, or for the first time even, since they might be unaware of the progresses made each season.

### **Contribution**

This study is another step towards developing the Swedish wine sector. It will serve as a basis for further improvements by showing what the sensory profile of Swedish wine looks like today, it will provide information on the actually situation of the Swedish wine sector from the opinions of wine producers and wine experts. By empirically researching the situation it could be possible to point out what further research should focus on.

During my five year education in horticultural science I have during the final years focused on cool climate viticulture as it is a very exciting area with great possibilities. My bachelor thesis (15hp) was on *Useful methods of analysis during processing of wine*, I have attended courses at University of Copenhagen in *Fundamentals of Beer brewing and Winemaking*

(7,5hp) and *Applied Cool Climate Viticulture and Enology* (15hp) and in addition while at University of Copenhagen I conducted an individual study called *Polyphenols as natural antioxidants in wine* (7,5hp).

Given this context the issue is the need of a sensory profile of Swedish white wine today and investigation of cool and cold climate viticulture literature, opinions of wine producers and of wine experts to suggest further improvements of Swedish viticulture to strengthening the perception of Swedish wine. White wine seems to be the most promising wine style to produce in Sweden and therefore the sensory profile was carried out for white wine.

### **1.3 Aim and limitations**

The aim of the study is twofold, to show a sensory profile of Swedish wine today and to investigate the opinion of both wine producers and wine experts on viticulture in Sweden and wine from grapes grown in Sweden.

Research questions were formulated to direct the thesis:

- *What is the sensory profile of Swedish white wine?*
- *What will a contextual analysis tell about the situation in Sweden and viticulture in other cool and cold climate regions comparable with Swedish climate?*

More precise research questions will be formulated in Chapter 3

#### **Theoretical limitations**

Literature on viticulture and oenology widely exists, however, naturally often focusing on the traditional wine regions. Literature on cool climate viticulture is not difficult to find, although some of the books available are a bit dated. However, the literature on cold climate viticulture is less numerous. A main challenge was to find definitions of what is cool and cold climate when it comes to viticulture. The examples presented in this thesis are those that divide the regions by which grape varieties that will sufficiently ripen (Jackson and Schuster, 1987, Plocher and Parke, 2008).

#### **Methodological limitations**

The vineyards and wine experts to be interviewed were chosen on a purposive sampling technique. Six Swedish vineyards, one Danish vineyard and five wine experts were chosen as basis for the research. The conclusions of this thesis will not be made on a whole population but rather on theoretical generalization.

## **Empirical limitations**

The reviewed literature of this thesis comprises of books available at SLU library and also articles available electronically from the same library. Also books offered at the library of Malmö were used. Furthermore literature of interest was obtained through other sources.

The research was conducted from southern Sweden because of the location of the researcher. However, since the largest percentage of Swedish vineyards is located in this area it is thought that the analysis will still provide a fair overview of the situation.

## **1.4 Outline**

- *Chapter 1* introduces the problem, the research questions, the aim and the limitations of the research,
- *Chapter 2* contains the reviewed literature and the contextual analysis relevant for the research questions. The reviewed literature was the basis and inspiration for the interview guide,
- *Chapter 3* presents the research methods,
- *Chapter 4* presents the results from the interviews and the sensory analysis,
- *Chapter 5* discusses and compares the results in relation to the literature in order to answers to the research questions,
- *Chapter 6* concludes the thesis.

## **2 Literature study**

*The following chapter provides an understanding of cool and cold climate viticulture and oenology and of how countries with similar climate as Sweden have developed their viticulture sector. Wine styles that are of interest are described, the origins of different wine flavours, the economy and tourism aspect of viticulture in new viticulture regions and finally the elaborated research questions are presented to sum up the literature study.*

### **2.1 Chemical constituents of wine determining the sensory experience**

It is explained by Jackson (2008) that the few compounds that occur individually at concentrations above 0,1 g/liter are the primary sources of for the taste and mouth-feel sensations of a wine, namely water, alcohol (ethanol) fixed acids (primarily tartaric acid and malic or lactic acids), sugars (glucose and fructose), and glycerol. In red wine tannins are important flavour enhancing substances, in white wines they occur in moderate amounts unless they have been matured on oak. Normally combinations of influences from many

aromatic compounds, not a single varietal unique substance, give rise to distinctive aromas. Chemical compounds can interact in complicated ways to influence the sensory perception. The most important aromatic compounds are volatile acids, fusel alcohols and fatty acid esters.

Additionally Jackson (2008) describes that the primary wine yeast is *Saccharomyces cerevisiae* which obtains most of its metabolic energy from glucose and fructose, therefore grape sugar content is essential to yeast growth and metabolism. The sugar content in the grapes varies depending on the species, variety, maturity, and the health of the fruit. A normal component in wine is sulphur dioxide, accumulating as a result of yeast metabolism. Sulphur dioxide is unwanted in excess but it has benefits such as antimicrobial and antioxidant properties. To limit oxidation and microbial spoilage wines are normally given a small dose of sulphur dioxide at bottling (Jackson, 2008).

Malic acid constitute about half of the total acidity of grapes and wine and is one of the prime indicators used when determining the harvest date together with sugar concentration as described by Jackson (2008). As the grapes mature the concentration of malic acid decreases especially during hot periods during the end of the season. However, at cool climate conditions the malic acid level can remain high and the finished wine is given a sour taste, but in hot climates if the malic acid disappears it can lead to a flat taste and susceptibility to microbial spoilage (Jackson, 2008).

## **2.2 Cool and cold climate viticulture**

Jackson and Schuster (1987) define a cool climate, for viticulture, as one that will have the capacity to produce table wine of distinction. A typical characteristic of a cool climate area is that the quality of the wine will vary between the seasons, causing that some are labelled good vintages, some average, and some poor. The climate can also be classified as by the types of grapes that will ripen satisfactory. In cool regions, especially in those near the cooler limit, several problems can occur, frost may damage the crop in spring or autumn, and in cold summers the grapes may not ripen satisfactory. However, winemaking can be economic even at the cooler limits since in better years, quality is excellent and high prices may be attained (Jackson and Schuster, 1987).

The primary factor controlling the growth of grapes for production of high quality wine is the climate (de Blij, 1985, Jones, 2012). Jackson and Cherry (1988) found that calculating the

latitude-temperature index (LTI) was the most satisfactory to use when distinguishing the ripening capacity. Following equation is used to calculate LTI with MTWM (mean temperature of the warmest month):

$$\text{LTI} = \text{MTWM} (60 - \text{latitude})$$

However, irregularities can be found. For example Rheingau and Moselle should according to LTI not be able to ripen Riesling, nevertheless these areas are known to produce fine Riesling wines. Yet only on the warmest slopes grow Riesling, the cooler areas grow cultivars less demanding (Jackson and Cherry, 1988). Calculations of LTI for locations in Sweden are found in Appendix 8. Eckersten et al. (2008) calculated HI (Huglin index) for Lund, Sweden after Trnka et al. (2011), which between 1981 and 2010 had a mean HI of 1252 whereas the main wine regions in Europe have around 1800 or more.

### **2.2.1 Choosing the growing site and grape varieties**

Examining the regional weather and climate should be the first step when evaluating a new vineyard site according to Plocher and Parke (2008). After assessing the regional climate, it is possible to consider which grape varieties could grow and fully ripen on the site, which type of training system would be suitable and if winter protection will be needed. While examining the regional climate aspects such as spring and fall frost susceptibility, heat deficiency for inflorescence and ripening will be emphasized. Lacks in the regional climate can at times be compensated for by site characteristics as for instance good elevation, south facing slopes, and wind protection (Plocher and Parke, 2008). Although it is of importance to choose a grape variety that will ripen on the site, consideration should be taken in to account that many hardier varieties produce a wine of poor quality and taste. The grape varieties planted should therefore be those that are most suited for the unique conditions of the climate, but also produce a product of interest for the market (Gustafsson and Martensson, 2005). Jackson and Schuster (1987) grouped grape varieties according to ripening ability in Group A (LTI < 190), and subcategorized that group into *very cool* and *cool* climates, and Group B (LTI 190 – 270). Varieties such as Madeleine Angevine, Schönburgunder, Müller-Thurgau and Triomphe d'Alsace was placed in the very cool zone of Group A and in the cool zone varieties such as Pinot gris, Pinot noir, Pinot noir, Sylvaner, Kerner and Chardonnay was found. In Group B there was Riesling and Pinot noir, however, in this LTI Pinot noir would produce a heavier wine unlike the lighter style made in Group A. In Appendix 8 LTI for locations in Sweden can be found, for example Anderslöv in southern Sweden had a LTI of 78 in 2013.

### **2.2.2 Favourable microclimate**

In a cool climate region finding sites with favourable microclimates is a necessity for establishing a vineyard. In Quebec and Nova Scotia, Canada the vineyards are relatively small (1-12 ha) in order to take advantage of well suited microclimates (Jones, 2012). A study shows that in Denmark there is a tendency that the highest yields are from small fields, probably because of better locations. On wider and more open vine fields the general weather conditions have a greater impact on the yield (Smith and Bentzen, 2011). The growing season will be extended by increased temperature in both spring and autumn with wind protection, although some aeration of the vines is valuable with the purpose of reducing the risk of fungal attacks. In Scandinavia it is suggested that a vineyard should be situated on a south or south-west facing slope with a windbreak against the north wind (Gustafsson and Martensson, 2005). The vineyards in Quebec are between the 45° - 45,5°N latitude range, and they will survive the best if they are located near a small water body to benefit from moderating affects and/or are situated on south facing slopes in order to profit from spring, summer and fall sunshine, and the vineyards are also protected from cold winds in all seasons (Jones, 2012). Vineyard site variables such as elevation and slope are especially important in regions where there is a high susceptibility to early autumn frosts. An early autumn frost will interrupt the ripening of the grapes, but also the maturation of next year's fruiting canes (Plocher and Parke, 2008). From a Danish study the authors state that there is less risk of frosty nights in late spring and conditions are sunnier during the growing season if the growing site is close to a coastal area, although, in the summer, being close to the sea implies colder temperatures during the day (Smith and Bentzen, 2011). Results from Pedneault et al. (2013) also showed that vineyard conditions should be analyzed closely and seriously considered when choosing grape varieties to implant.

### **2.2.3 Winter climate**

When assessing the regional climate, as a grape grower in a cool or cold climate, attention should be put on the winter climate of the region. A milder winter climate is preferable, but not required. It is of more importance to realistically and correctly visualize the winter climate of the site with the aim of making good decisions of what kind of viticulture is achievable and what specific requirements for the site are needed. Factors that could be considered are, temperature fluctuations, snow cover, absolute cold, estimating spring and fall frost susceptibility, autumn rainfall, phenological observations of other plant species commonly grown in the area, and finally, is the source of the information reliable (Plocher and Parke,

2008)? The most important climate element affecting grape growing for wine production, however, is temperature. It defines the length of the growing season and also the varieties suited to any region, their potential wine style and quality (Smart, 2011).

#### **2.2.4 Acclimatization of the vine**

Shortly after *véraison*, the turning point that signifies the beginning of a fundamental physiological shift culminating in berry maturation (Jackson, 2008), the first stage of the vine's acclimatization process begins. To support ripening and sugar storage, the flow of photosynthates concentrates in fruit clusters, roots and perennial parts of the vine instead of supporting new shoots growth. Also the water content of the vine's tissues is reduced to increase the concentration of natural antifreezes (cryoprotectants) in the tissues. In late summer and early autumn, the decreasing day length and the declining temperatures will stimulate the vine to harden off. Vines can sense the shift and begin to acclimatize to the cold well ahead of autumn frosts. *V. riparia* vines will acclimatize especially early (Plocher and Parke, 2008). For most winter hardy species the buds and canes are prepared to withstand temperatures around -15°C to - 18°C in mid-October. However, the ability of grape species and varieties to produce natural cryoprotectants substances and attain deep levels of supercooling varies greatly and there are limits to protection by supercooling and biochemical protectants. Fluctuating temperatures can cause unexpected problems. Unexpected below 0°C cold spells can damage a vine that is still acclimatizing to the cold. This could particularly be a problem when the late autumn temperatures are mild or there is extreme rainfall during the early autumn and the second stage of cold acclimatization starts late or advance slowly (Plocher and Parke, 2008). Sudden autumn frost can damage the vine by burning the leaves and production of additional energy to fully mature the grape is inhibited or the vine is prevented from building enough carbohydrates to be prepared for winter, making it additionally sensitive to low temperatures. A frost during spring can also damage the vine and kill the buds, limiting the production for that season (Belliveau et al., 2006). Furthermore in mid-winter, during sudden warm spells above 0°C the vine can start to deacclimate and reverse progress towards deep acclimation. It is dependent upon the state of endodormancy if the vines will deacclimate due to a warm spell, since a vine will refuse to deacclimate in response to warmth during a period of time. *Vitis vinifera* vines have evolved in climates with fluctuating mid and late winter temperatures and they are likely to remain well acclimated regardless of winter warm spells and deacclimate at a, due to the climate, suitable time (Plocher and Parke, 2008). On the other hand, *V. amurensis* and its hybrids, Michurinetz for

example, have early winter hardiness, but during mid and late winter thaws they are very prone to deacclimate fast since *V. amurensis* is well adapted to the Siberian climate in which the first thaws signal spring. Interspecific hybrids can end up anywhere in between the two extremes. Prior to pruning in the spring, winter injuries should be assessed to determine how the vines must be managed throughout the spring and summer (Plocher and Parke, 2008).

### **2.2.5 The importance of solar radiation**

Solar radiation and heat ensure that sugars are accumulating in the ripening grapes, acidity is reduced and colour and flavour components are developed. However, during spring and early summer the vine also requires sunshine and heat for growth, bloom, and fruit set. South facing slopes will have an advantage in solar reception throughout the whole growing season, but the most advantage will be gained during September and October. It is during the autumn months that the grapes are in need of the heat to finish ripening well enough for the wine. Compared to a level site, a south facing slope of just 15 degrees will obtain 22,5% more solar radiation during mid to late September (Plocher and Parke, 2008). It would also be beneficial if the vineyard is situated so that cool rays of early morning sun is avoided, while the warm rays of evening sun are utilized as much as possible (Gustafsson and Martensson, 2005).

Additionally, the slope and the soil type will have a strong impact on the water household of the vineyard, water deficit is one of the major components of the so called ‘terroir effect’ (Van Leeuwen and Seguin, 2006, Zsofi et al., 2011). Irrigation experiments have shown that mild to moderate water deficit will result in higher sugar levels in fruits compared to fruits that have not been stressed (Roby et al., 2004, Zsofi et al., 2011).

### **2.2.6 Climate changes allows more varieties to ripen**

French-American hybrid varieties, primarily Seyval Blanc and Maréchal Foch, dominate the wine industry in southern Quebec. The climate has not permitted the use of French-European *Vitis vinifera* grapes. Yet, studies now show that the climate is changing in the area, the winters are not as harsh with fewer intense cold days and the growing season is becoming longer (Jones, 2012). However, a study conducted in Western Canada showed that a raise in regional warming and thus longer growing seasons would allow production of higher quality grapes such as *V. vinifera*, but for the growers in that particular area (Okanagan), there would also be a challenge with water availability for irrigation associated with climate change (Belliveau et al., 2006, Jones, 2012). Furthermore, a longer growing season will not just permit the grapes to ripen sufficiently, heat and sun are also important for allowing cane maturation and winter preparations to conclude optimally (Plocher and Parke, 2008).

Holland and Smit (2010) identified challenges and opportunities for wine-producing regions of the world. Furthermore it was also found that little is known about the vulnerability of viticulture and viniculture as a sector to conditions beyond temperature and climate; about the adaptive capacity of the wine industry; and about adaptive management strategies and therefore suggests future research to identify adaption options that will ultimately reduce the vulnerability of the international wine industry to climate change.

## **2.3 Cool and cold climate countries with viticulture**

### **2.3.1 England**

The climate of England provides relatively few sunshine hours, rather low summer temperatures, and high precipitation making fungal diseases an obstacle. The growing degree days above 10°C (GDD) are between 750 and 900 or using LTI it is 130-160, however, the risk of autumn frost is low and being forced to harvest due to frost will not occur, giving England the advantage of a longer growing season although spring frost can be more common. *V. vinifera* varieties are more common in England, even though the interspecific varieties are more resistant to diseases. The most frequently grown are Müller-Thurgau, Reichensteiner, Seyval Blanc, Bacchus, Schönburger, Madeleine Angevine and Huxelrebe (Gundersen and Génsbøl, 2007).

Due to improvements in wine production techniques, together with a changing climate and the presence of geological formations similar to those found in the Champagne region, it is increasingly possible to grow and produce high quality sparkling wines in south east England. It is thought that this could reduce wine imports to the UK, and furthermore offer diversification potential to farms in south east England, while creating new employment opportunities. Geographic Information Systems (GIS) was used to find the best locations for growing vines. It was found to be a satisfactory tool that could analyze where in the region particular combinations of geological, topographical and meteorological factors combine to reproduce the conditions likely to produce quality grapes and key areas were found. However, the factors that contribute to the quality of Champagne are poorly defined and it is not currently possible to apply them to the south east of England in a manner suitable to establishing the 'best' or most appropriate sites for growing vines. The study demonstrated the value of GIS as an analytical tool and identified 11 environmental parameters contributing to the quality of wines, and for each parameter, a threshold value was established beyond which viticulture becomes marginal. The parameters identified were pH, depth to bedrock, soil drainage,

organic matter, the GDD, total annual rainfall, frost days during growing season, average wind speed over growing season, angle of slope, elevation and aspect, see more detailed in Appendix 2 (Foss et al., 2010).

Plumpton College, East Sussex, is the only higher education institution offering undergraduate degrees in Wine business and Production in English in Europe and first started offering courses in 1996 (Plumpton College, 2014).

### **2.3.2 Canada**

Viticulture in Canada developed through growing of the local species *V. labrusca*, and today the growing area is of approximately 8000 ha. The four main areas are British Columbia in the west, Ontario and Quebec by the big lakes in the east close to the USA-border and Nova Scotia by the Atlantic coast. Gundersen and Génsbøl (2007) also state that Nova Scotia is the area of most interest due to the climatic similarities with Denmark. First generation hybrids such as Maréchal Foch, Baco Noir and Vidal dominate the Canadian viticulture areas, however, the amount of *V. vinifera* varieties is increasing.

Vintner's Quality Alliance (VQA) Ontario is Ontario's Wine Authority:

“...a regulatory agency responsible for maintaining the integrity of local wine appellations and enforcing winemaking and labeling standards. VQA Ontario does not represent the wine industry in Ontario and is not a marketing agency.” (VQA, 2014a)

A VQA wine will ensure that the wine is made from 100% fresh Ontario grown grapes, that the wine meets the quality standards, for instance the wines have been evaluated by an expert taste panel, gone through a laboratory analysis and must meet the minimum quality standards before release (VQA, 2014b).

At Brock University CCOVI (Cool Climate Oenology and Viticulture Institute) is found. It was established in 1996 in partnership with Grape Growers of Ontario and the Wine Council of Ontario. CCOVI is an internationally recognized institute focusing on research priorities of Canada's grape and wine industry and the education and outreach needs of that community. As the institute has grown, the focus has expanded from the science behind viticulture and oenology to areas within the grape and wine value chain such as wine business, policy research and agri-tourism. A network has been created in the area and also with Acadia University's Atlantic Wine Institute in Nova Scotia (CCOVI, 2010). Educations and training can also be found at Univeristy of Bristih Columbia, Niagara College, Okanagan University

College, University of Guelph and Nova Scotia Agricultural College as described by Doloreux and Lord-Tarte (2012) in the same study a more detailed description of Canadian support organizations in the wine industry can be found.



Image 1. Map of Canada (Wikipedia, 2014).

### 2.3.3 Sweden

In Sweden common varieties are first generation hybrids such as Léon Millot and Maréchal Foch, and later evolved interspecific varieties such as Orion, Sirius and Regent (Gundersen and Génsbøl, 2007). The Swedish island Gotland have very moderate winter temperatures and approximately 900 GDD (Plocher and Parke, 2008). The most common grape varieties in Sweden are however, Rondo and Solaris (Vinvägen, 2014).

The association *Svenska Vinodlare* aim to unite growers and enable cooperation throughout Sweden. The association welcomes all types of winegrowers, from large-scale growers with commercial ambitions to the hobby grower with a few vines in the garden. Occasionally it is possible to purchase Swedish wine at the alcohol monopoly company *Systembolaget*, however, *Svenska Vinodlare* consider it a key factor in order to develop Swedish viticulture commercially, together with tourism, for the vineyards to be allowed to sell their wine on site (Svenska Vinodlare, 2014b).

The Swedish wines sold by *Systembolaget* are part of the ‘exclusive assortment’ which are product with limited availability at a relatively high price. The products are purchased by *Systembolaget* without going through blind tests, upon agreement with the buyer in question (Systembolaget, 2014).

#### **2.3.4 Denmark**

The German grape variety Rondo is the most important variety in Denmark, both for producing single grape red wine and as a basic component in blends. The second most common varieties are Léon Millot and Regent (Smith and Bentzen, 2011). Other common varieties are German Phoenix, Hungarian Reform and French Castel 13,937 (Plocher and Parke, 2008). New varieties are regularly introduced, especially Cabernet varieties (Smith and Bentzen, 2011).

*Danske vinavlere* is the association uniting Danish winegrowers, both hobby growers and commercially active growers and producers. The association exists to foster and increase the quality of Danish viticulture and wine production (Danske Vinavlere, 2014).

University of Copenhagen offers the course Applied Cool Climate Viticulture and Enology (15 ECTS). The course is addressed to students within horticulture, agriculture and food science and technology. A fundamental and applied understanding of wine cultivation and processing will be given and the complex effects on final wine quality will be elaborated (KU, 2013).

#### **2.3.5 New Zealand**

The south areas of New Zealand, Canterbury and Central Otago, have a cold climate and is interesting in relationship to Denmark. The GDD falls between 900 to 1100 and 850 to 1000 and the LTI are between 277 and 260. In these two regions varieties such as Riesling, Müller-Thurgau, Chardonnay, Sauvignon Blanc, Gewürztraminer, Pinot Blanc, Pinot Gris, Pinot Noir and Cabernet Sauvignon are commonly grown. The sugar and acid values obtained are similar to values obtained in Denmark. New Zealand is considered to be one of the most promising new wine producing countries in cool climates, especially for white table wines. The best New Zealand wines have their strength in the ability of bringing out the character of the grape variety by giving it an intense fruity flavour and balancing it with the acidity (Gundersen and Génsbøl, 2007).

### **2.3.6 Tasmania (Australia)**

The wine industry in Tasmania has looked to nearby New Zealand to assess the potential of Tasmania as a grape growing region. New Zealand is one of the most exciting and thriving New World wine nations because of its cool climate, producing impressive growth rates and premium quality, cool climate wines. The temperature climate of Tasmania is very similar to parts of New Zealand and it would be possible to find places with similar climate that would parallel most of the New Zealand wine regions with Tasmania. As the islands are of similar size and latitude, and are washed by similar ocean currents it was not surprising that they have very similar climate (Smart, 2011).

*Wine Tasmania* is an advocacy group for Tasmanian growers and wine producers, focusing on assisting them to be recognised as world leaders in the sustainable production of premium cool climate wine, and with a vision to establish Tasmania as a benchmark wine region of world renown. It is an independent, non-profit organisation, financed by its member businesses, with additional funding sourced from corporate sponsors and project-based external funding, including government. Built on quality and value the Tasmanian wine sector has developed a strong, clear and collaborative position in the wine world (WineTasmania, 2013).

## **2.4 Grape varieties for cool and cold climate regions**

Factors to consider when choosing which grape variety to grow are for example, hardiness, ripening period, spring frost susceptibility, and wine suitability. In the amount of heat and number of frost-free days required to produce grapes, with chemistry useful for winemaking, the time of ripening can be described correctly. For varieties such as Seyval and Frontenac, they will often lack full development of their varietal flavour at a sugar content of 19 °Brix, Seyval will taste citric and Frontenac will taste herbaceous. On the other hand for varieties such as Rondo, Joffre, Millot, and Castel 19,637 an acceptable wine can be produced at 19 °Brix, with characteristic flavours (Plocher and Parke, 2008). Depending on the grape variety and available sun and heat, a vine has the ability to mature a limited amount of fruit. More energy can be made available to the grapes if the cropload is reduced, allowing the remaining fruit to mature and also reach a higher quality (Belliveau et al., 2006).

### **2.4.1 Flowering and fruit set**

If the site is susceptible to late spring frosts, a variety that either begins growth late or has a slow growth rate following bud break will be suitable. Following bud break the growth rate

will differ between varieties. During the period prior to bloom and during blooming cold and wet conditions can be common in cool climates grape growing regions. Pollen tube growth and development in most grape species and varieties can be averted by temperatures below 12,7 °C (Plocher and Parke, 2008). At bloom excessive rain will hinder pollination or fruit set, and at harvest too much rain will cause the grapes to swell, diluting the final flavour of the wine. The flavours and colours are all found in the skin of the grape, therefore a small grape with a high skin to juice ratio generate a more concentrated, stronger and fruitier wine than a large grape would (Belliveau et al., 2006). Yet even under the most unfavourable conditions some interspecific hybrids have shown an unusual ability to grow and set fruit. Varieties such as Rondo, Reform, Hasansky, Zilga, Sukribe, Sladky, and Jubilinaja Novgoroda were found to be the most reliable for fruit set in cool wet climates (Plocher and Parke, 2008). Diurnal temperature fluctuations in the region can lead to increased concentrations of aromas and volatiles and thus higher grape quality. In Scandinavia, the fluctuations in day and night temperature are unique and can be taking advantage of by choosing the appropriate harvest date (Gustafsson and Martensson, 2005).

#### **2.4.2 Breeding programs developing cool and cold hardy grapes**

Northern viticulture is a relatively recent development, and it can be directly related to cold-hardy grapes arriving on the market. Breeding programs at University of Minnesota (St. Paul, MN, USA) and the Horticultural Institute of Ontario (Vineland Station, ON, Canada) have developed most of these varieties among other institutions. The new varieties are usually interspecific hybrids of *V. vinifera*, with the North America native species *V. labrusca* and *V. riparia* (Fisher and Fuleki, 2000, Pedneault et al., 2013). Poland is a cool climate region where grape growing and winemaking has been made possible due to emergence of new grapevine varieties composed of hybrid varieties that are better suited for the Polish climate (Tarko et al., 2010).

In southern Ontario, Canada, it is difficult to use cultivars developed elsewhere because of their harsh winters and high disease pressure. Cultivars that will tolerate both climatic and pest pressures, not pass on an unpleasant flavour to the wine, and produce adequate colour even in cool vintages are needed (Fisher and Fuleki, 2000). One of the coldest regions of the world where grapes are grown commercially is Minnesota, USA. Grape breeding at the University of Minnesota has recently focused on the development of cold hardy and disease resistant varieties derived from *V. vinifera* or French hybrids and *V. riparia* (Hemstad and Luby, 1998, Hemstad and Luby, 2003). The first new cultivar was Frontenac released in

1995. La Crescent is another grape variety from the University of Minnesota's grape breeding program that has shown extreme cold hardiness and high wine quality. It has a relatively high sugar content and acidity levels are also high which led to winemakers fermenting it in as semi-sweet style and it is believed to be of value too growers in regions where winter hardiness is a limiting factor (Hemstad and Luby, 2003). In Quebec and the U.S. Frontenac is now the main red cultivar that is planted, mainly for the fruitiness of the wine (Mansfield et al., 2011, Pedneault et al., 2013). Marquette is also a new variety, released in 2006, it has a short growing season allowing the grapes to ripen within 1100 GDD (based on 10 °C) and it has a lower acidity compared to Frontenac, making Marquette a promising variety for cool climates (Pedneault et al., 2013).

### 2.4.3 Grape varieties

Most of the commercial varieties are pure *V. vinifera* varieties. The next largest group is French-American hybrids, derived from crosses between *V. vinifera* and one or more of the following: *V. riparia*, *V. rupestris*, and *V. aestivalis*. Early American cultivars are either selections from indigenous grapevines, or are hybrids between them and *V. vinifera*. Modern crosses between *V. vinifera* and species such as *V. amurensis*, *V. riparia*, *V. armata*, and *V. rotundifolia* are referred to as interspecific varieties (Jackson, 2008). A more detailed description of grape varieties interesting in cool and cold climate viticulture can be found in Appendix 1. In table 2 Hardiness and ripening period of grape varieties suitable for cool and cold climate regions is displayed and the grape varieties popular in Sweden, Rondo, Solaris, Leon Millot, can be found in the group termed tender and they are in need of winter protection in order to survive temperatures below -26°C (Plocher and Parke, 2008).

**Table 1. Hardiness and ripening period of grape varieties suitable for cool and cold climate regions. Ripening period described with Roman numerals: I = Ultraearly; II = Early; III = Midseason; IV = Late season (used with permission) (Plocher and Parke, 2008).**

Hardy to -40 °C		Hardy to -35 °C		Tender	
Reds	Whites	Reds	Whites	Reds	Whites
D.M. 8521-5 (II)		Hasansky Sladky (I)	E.S. 8-2-43 (II)	Rondo (II)	Solaris (I)

Troubador (III)	Skandia (I)	Edelweiss (II)	Castel 19,637 (II)	Muscat Ustoicznyvj (II)
Valiant (II)	Marquette (II)	Louise Swenson (III)	Leon Millot (III)	Reform (II)
	St. Croix (III)	Prairie Star (III)	Marechal Foch (III)	Seyval Blanc (III)
	Sabrevois (III)	Brianna (III)	Holuboc (III)	
	Black Pearl (III)	E.S. 6-16-30 (III)	Temparia (IV+)	
	Frontenac (IV)	St.Pepin (III) La Crescent (III) Lacrosse (IV) Frontenac Gris (IV) Frontenac Blanc (IV)		

## 2.5 Wine styles

Plocher and Parke (2008) suggests that in cool and cold climate winemaking a more manipulative role is required of the winemaker, due to the fact that the grapes usually have not ripened optimally, compared to winemaker in regions of more favourable climate where after a good season they should not disturb what is already in the grapes and will therefore interfere in the winemaking process as little as possible. Depending on the characteristics of the grape variety and harvest conditions the most suitable winemaking style can be chosen. The grape variety at hand will often affect the wine style choice greatly. The choice of wine style will impact or dictate harvest factors, skin contact, fermentation temperature, and yeast selection, and the choice should be made early. Classic styles are for example; Germanic style whites, Alsatian style whites, neutral whites, full-bodied white varietals, dessert whites, sparkling wines, rosés, fruity reds, medium-bodied red varietals, Rhone style reds, full-bodied red varietals, late harvest reds, and generic wines (Plocher and Parke, 2008).

### 2.5.1 Conditions affecting the wine style

The variety, year of harvest, vineyard location, climate conditions, microclimate, soil type and vineyard practices all influence the chemical composition of the grapes. In addition to natural changes of the environmental conditions the vines are exposed to natural stress factors such as unsuitable temperature, too much or too little sunshine and watering, and furthermore, stresses from human activity such as acid rain, air pollution, and heavy metal pollution, all factors influencing plant physiology progression and also the amount of antioxidant compounds (Tarko et al., 2010). Anthocyanins, tannin monomers and tannin-anthocyanin

polymers are the phenolic compounds determining the taste and appearance of the wine. The preservation of wine quality during the production of red wine is preserved due to the fact that these phenolic compounds also have strong antioxidant capacities (Mercurio et al., 2007, Damberg et al., 2012). Red wines obtain its colour through maceration, during this process phenolics are leached into the must from grape seeds, skins and stems. Results from trials by Damberg et al. (2012) showed that both total and pigmented tannin concentrations were higher in wine undergone extended maceration and wines with stems added also had high tannin content, but not pigmented tannin, for Pinot Noir wine. Damberg et al. (2012) suggests that year-to-year consistency of wine style is achievable through carefully chosen maceration methods, together with suitable grape and phenolic profile measurements. Analyzing phenols in grapes and wine together with intervention in the winemaking procedure is a way of compensating for seasonal variations often occurring in cool climate wines.

The growth of the grapes occurs in three stages; first there is a period of rapid growth followed by a slow growth period and finally another rapid growth phase prior to maturity. At the end of the second growth period there is a dramatic change in the course of development called *véraison*. At this point the growth accelerates again and the grape begins to soften, glucose and fructose increases, acidity decreases, the chlorophyll is lost and the colour develops in red and black varieties. Acid levels are high at *véraison* but afterwards it is reduced by dilution as there is an inflow of water into the berries and acids are converted into salts. Firstly tartaric acid drops and then remains relatively constant and secondly malic acid drops at a constant rate and might even disappear. In cool climates though, the level of malic acid remains high longer compared to hot climates. Wines from cool climate regions are characterized by higher acidity levels. The wines are more complex and normally need a longer period of maturation to achieve balance, in cold years excessive acidity can be a problem (Jackson and Schuster, 1987).

It is suggested that in cooler grape-growing regions sugar concentration at harvest can be low although the grape is physiologically ripe and the composition of aroma and acid necessary for producing quality wine is satisfactory. Wines produced from such grapes will naturally have a lower alcohol content, such as 8 - 10,5%, yet still maintaining much of the sensory characteristics and balance of their full-strength equivalents. High quality wine cannot be produced from anything but high quality fruit. Low-alcoholic wine (0,5 - 6,5% alcohol) is a product often produced from low quality grapes (Pickering, 2000). It was confirmed that

wines with 0 - 10% alcohol were perceived as lower in viscosity and weight, whereas wines above 10 – 12% alcohol were not (Pickering et al., 1998, Pickering, 2000)

### **2.5.2 Blending to obtain a pleasant wine**

Generally, although a vine is hardy in a cool climate does not mean that it will make a pleasant wine, in fact, few hardy varieties will make enjoyable single variety wines. However, Plocher and Parke (2008) also states that northern winemaking is not about producing varietal wines. It is more regarding blending two or more varieties to attain a balanced product.

Blending can often adjust flaws that many cool climate wines have, for example it can add aroma and flavour characteristics, and balance the wine in a way not achievable otherwise.

Blending can approve the colour, flavour, acidity, tannins, and the nose of the wine (Plocher and Parke, 2008). The preferred grape in Denmark, for red wines, is Rondo, from which it is easier to reach higher sugar content. Solaris, the preferred grape for white wine, is early maturing which is obviously beneficial for cool climate regions. Whereas Phoenix seems to be a tricky and demanding grape from the Muscat tradition, which only seems suitable for a few local growing conditions in Denmark. The natural sugar content of the grapes is a significant factor for producing wines of high quality, but it is also a quality indicator of the grapes at harvest. Good growing conditions are indicated by high grape sugar content of the grapes at harvest and optimal maturation is more likely and stronger and more full-bodied wines will be attained from Danish growing conditions (Smith and Bentzen, 2011).

## **2.6 Wine flavour and sensory attributes**

Among the vast range of wine and wine styles produced throughout the world one of the main characteristics defining the differences is the aroma and flavour of wine (Swiegers et al., 2005). The interaction of chemical components with the sense of taste and smell of the consumer results in what is called flavour. Flavour is composed of volatile compounds, accountable for the odour, and non-volatile compounds responsible for taste sensations, such as sweetness, sourness, bitterness and saltiness. The flavour sensations in wine experienced by the palate are caused by sugars, organic acids, polymeric phenols and mineral substances. The compounds need to be present in levels of 1% or more, with a few exceptions, to influence taste. Usually much lower concentrations are necessary to perceive the volatile compounds, as our sense organs are extremely sensitive to certain aroma substances (Rapp and Mandery, 1986). Wine aroma can be classified as:

- Primary or grape aroma: aroma compounds possible to find in undamaged plant cells of grapes.
- Secondary grape aroma: aroma compounds formed by actions such as destalking, crushing and pressing, and by chemical, enzymatic-chemical and thermal reaction in the grape must.
- Fermentation bouquet: aroma compounds derived from the alcoholic fermentation.
- Maturation bouquet: formed by chemical reactions during maturation of the wine in the bottle (Rapp, 1998).

The levels of wine aroma compounds can be affected by several different factors for example environmental factors such as climate and soil, the cultivar, the condition of the fruit, the degree of ripeness, the circumstances during fermentation such as pH, temperature, juice nutrients, and microflora, and different postfermentation treatments such as clarification, blending etc, and bottle maturation, e.g. aging, of the wine (Rapp and Mandery, 1986, Rapp, 1998).

### **2.6.1 Grape aroma**

Esters add to the intense and characteristic aroma of *V. labrusca* and *V. rotundifolia* cultivars, whereas for *V. vinifera* cultivars there are only a few esters, occurring in small quantities adding to the aroma. Aldehydes are found in grapes or grape juice, C<sub>6</sub>-aldehydes and alcohols are formed enzymatically upon grape cell destruction (Rapp and Mandery, 1986). Terpenes are present in the grapes, mostly in the skins, and the levels increase with berry maturation (Park et al., 1991, Ebeler and Thorngate, 2009). Park et al. (1991) also showed in a trial conducted in California that monoterpene accumulation is not related to sugar accumulation, a maturity indicator widely used, since both free and bound monoterpenes continued to increase after sugar accumulation slowed down. Monoterpene alcohols and derivatives play a significant role for the aroma of muscat varieties such as Muscat blanc, Muscat d'Alexandrie and Morio-Muscat, and also for aroma related varieties such as Riesling and Suerebe (Rapp and Mandery, 1986). Hernández-Orte et al. (2002) claim there is close relationship between the composition of amino acids in the grape must and the wine content on some important volatile compounds.

### **2.6.2 Aroma created during fermentation**

The main part of the aroma arises during yeast fermentation (Rapp and Mandery, 1986) and factors such as availability of yeast nutrients and temperature during fermentation have great impacts on the formations of alcohols and esters (Ough and Amerine, 1967, Hernández-Orte et al., 2002, Ebeler and Thorngate, 2009). Quantitatively ethanol and glycerol are dominating

alcohols formed, followed by diols, higher alcohols (fusel alcohols), and esters. Ethanol has a distinctive odour but apart from that it also determines the body of the wine, fixes the odours, and balances taste sensations. Higher alcohols contribute to the complexity of a wine at concentrations below 300 mg/l, however, when the concentration exceeded 400 mg/l it is considered that it contributes negatively. Small changes occur to monoterpenes during fermentation (Rapp and Mandery, 1986), they are extracted into the wine from the grapes during fermentation and contribute to the floral and citrus characters of wine (Park et al., 1991, Ebeler and Thorngate, 2009).

In young wines esters, formed during fermentation, are of significant importance. As mentioned before esters are present already in grapes in small amounts, but the main part of acetate esters and fatty acid esters are formed simultaneously as ethanol, the main ester being ethyl acetate. Esters of higher alcohols and short chain fatty acids, called fruit esters, are also created and are especially important to young white wine. The production of esters is greatly influenced by the type of yeast used but even more so the process is sensitive to fermentation conditions. The total concentration of higher esters is positively influenced by low fermentation temperatures (Rapp and Mandery, 1986). Ethyl acetate (ethyl ester) gives a solvent, nail polish aroma and isoamyl acetate (acetate ester) gives a banana-like aroma (Ough and Amerine, 1988, Ebeler and Thorngate, 2009). Most of the aldehydes present in grapes or grape juice are most likely reduced to alcohols since they are only detectable at the beginning of fermentation. With the exception of acetaldehyde which is formed during wine aging. Most of the ketones that are found in grapes are still present in the wine, although in small quantities. There are relatively few organic acids in wine that are volatile enough to contribute to the odour, except for acetic acid which can be detected. Volatile phenols found in wine are not present in grapes, they are derived from either yeast or bacterial metabolism or from hydrolysis of higher phenols. Even though there is no evidence that N-containing compounds produced during fermentation have an impact on the odour of the wine it cannot be excluded that they might have a sensory effect. Due to the fact that volatile organic sulphur compounds usually have very low perception thresholds, they are very important for the aroma (Rapp and Mandery, 1986).

### **2.6.3 Fermentation yeast**

Winemakers have numerous tools at their hands when producing wine with specific flavour profiles, one of them being the choice of microbial starter culture strains to carry out fermentation (Swiegers et al., 2005). The most essential part of wine flavour is formed during

the alcoholic fermentation. Various wine components such as acids, esters, ketones, aldehydes and S-compounds aside from ethanol and glycerol as well as diols and higher alcohols are formed during yeast metabolism. The dominating esters in wine, ethyl esters of straight-chain fatty acids and acetates of higher alcohols, are created during alcoholic fermentation (Rapp, 1998).

## **2.7 Economy and tourism**

Problems identified in the development of the Canadian wine industry are that the wineries are small-scaled and located in three different provinces, they are having limited sales, a low export rate, and they work in thin domestic markets (Doloreux and Lord-Tarte, 2012). In Ontario, Canada, wine tourism has allowed sales of wine through tasting rooms to become an important business activity. An advantage with a tasting room is that the winery can receive information directly from the consumer about their wine consumption, buying habits etc. Factors such as frequency of visitation can be assessed, e.g. will the consumer return for a second purchase (Bruwer et al., 2012). Additionally the consumers' willingness to purchase a bottle of wine is highly dependent on the reputation of the producer, the region, and the grape variety (Schamel and Anderson, 2003, Schroeter et al., 2011). The creation of VQA in 1988 significantly helped raising the quality of Ontario Wine in addition to raising the international profile. The VQA appellation system oversees the quality of the wines in both Ontario and British Columbia. By having the VQA symbol on a bottle of wine, producers can show that 100% of the grapes are from *V. vinifera* and authenticate the origin of the wine (Ziraldo, 1995, Telfer, 2001).

### **2.7.1 Expert quality ratings are beneficial for unknown regions**

In Denmark, the Danish Association of Wine Growers arrange the annual Danish Wine Contest in the same procedure as in the old wine countries, taking into account aspects such as nose, colour, and taste. Taste is thought to be the most important aspect. By winning an award at a wine contest the quality of the wine is acknowledged and the consumer choice is affected. Furthermore it appears to be a suitable approach with the aim of affecting consumer preferences and choice (Smith and Bentzen, 2011). Several studies show that expert quality rating could be of even more importance in cool climate regions because the wines are from lesser known regions and producers (Troncoso and Aguirre, 2006, San Martin et al., 2008, Schamel, 2009, Schroeter et al., 2011).

### **2.7.2 Producing wine that the customers want to drink**

Between the consumer groups 19-34 years old and 35 years and older differences in the wine consumption behaviour and wine type (sensory) preferences exists, found in a study conducted in Canada. In the same study it was found that tourism activities, especially the frequency of visiting a tasting room, offer opportunities for visitors to experience other wine types, leading to increased consumption of volume. Consumers in the group 19 – 34 years old drink less wine and spend less money on their monthly wine purchases compared with older generations, however, a good understanding of the younger group is important in terms of their future impact on the wine market. Aspirations and objectives in a consumer-oriented organisation are obtained through a thorough understanding of consumers' needs and wants. In the wine business/marketing field the adoption of a marketing orientation is only slowly becoming an accepted strategy. It is still an ongoing challenge for wine marketers to convince the wine producers to produce wines by focusing on what the consumers actually want to drink. It is suggested that preference mapping together with blind tastings could be a source a future research data (Bruwer et al., 2012).

## **2.8 Elaboration of the research questions**

*This section will describe the research questions additionally and elaborate the purpose of the research questions.*

The literature study presents the difficulties and opportunities of viticulture in countries with cool or cold climate lacking the tradition of viticulture. The contextual analysis describes how the viticulture sector has proceeded in countries of similar climate as Sweden, possibly pointing out future strategies for developing the Swedish wine sector and the interviews will provide an idea of the situation of Swedish viticulture today and hopes for the future. A sensory analysis will describe the Swedish wine today and is that the sensory profile which is expected by the wine producers and wine experts?

The literature reviewed served as inspiration for the interview questions and furthermore elaborated the research questions to the following:

*RQ 1: How should a white wine produced in a Nordic climate preferably taste according to winegrowers, winemakers and wine experts?*

*RQ 2: How do the winegrowers, winemakers and wine experts view upon the potential of Swedish/Nordic wine?*

RQ 3: *What is the sensory profile of Swedish white wine?*

RQ 4: *Based on the contextual analysis, what limitations and opportunities can be identified in the Swedish wine sector?*

The first research question (RQ1) aims to describe how the Nordic wine should taste in order to make it interesting on the market, since the Swedish market is dominated by quality wines in all price ranges from well-known wine regions.

RQ2 serves the purpose of outlining if there is a future of the Swedish wine sector. Can it compete with the well known wine regions?

The aim of RQ3 is to identify the sensory profile of Swedish wine today and furthermore connect it with the expectations from RQ1.

RQ4 will, based on findings from the literature study and the interviews, provide an overview of the structure of the Swedish wine sector today and try to suggest future possible improvements.

## **3 Methodology**

*The following chapter presents the research approach is presented. Chosen research strategies and methods will be described and the reason of the choice of them will be discussed. Data collection for the semi-structured interviews and the material for the sensory analysis will be presented.*

### **3.1 Research strategy**

This thesis has taken on a qualitative research technique by conducting semi-structured interviews and the sensory analysis gave quantitative results, therefore ‘mixed methods’ was the chosen research strategy. Semi-structured interviews were favoured since formulating precise questions was difficult. By interviewing both producers and wine experts it was made possible to compare the opinions on the situation of the two groups. A sensory profile was achieved through sensory analysis by a panel trained in sensory analysis. The method for sensory analysis is described by Hermansson (1999) and Lundgren (1981).

#### **3.1.1 Mixed methods**

Research combining alternative approaches within a single research project is referred to as the research strategy ‘mixed methods’. This study combines semi-structured interviews giving qualitative data with a sensory analysis giving quantitative data presented in spider charts. The basis for the mixed methods strategy is to combine qualitative and quantitative methods and therefore it is an appropriate approach for this study. The strategy mixed methods can also be used when there is an explicit focus on the connection between approaches called triangulation, or when there is an emphasize of practical approaches to solve research problems termed pragmatism (Denscombe, 2009).

A qualitative research approach is characterized by its unique approach to gather and analyze data, giving it a different character compared to quantitative research. Qualitative research comprises several social scientific approaches having in common that they for example utilize text and images as fundamental data, rather than numbers, an interest in meanings and the way whereupon people recognize things, and an interpretive approach regarding knowledge as socially constructed. Interviews are a source of qualitative data, as well as documents, observations, and surveys (Denscombe, 2009). Semi- structured interviews were chosen as one of the research methods for this project. Qualitative interviews are supposed to discover or identify unknown or unsatisfactory known phenomena, properties, or meanings, whereas

quantitative interviews has its foundation in beforehand defined phenomena, properties, or meanings formulated as questions with defined answers. The purpose of quantitative interviews is to investigate the distribution within a population of phenomena, properties, or meanings and/or how these covariate with other phenomena, properties, or meanings (Starrin and Renck, 1996). Qualitative and quantitative methods are tools and their applicability is dependent on the research questions (Kvale, 1997). Due to the fact that the possible interviewees are few a quantitative interview structure was not an option (Denscombe, 2009).

With mixed methods there is an increased accuracy, a more complete image is given, strong and weak sides can be compensated for, the analysis can be evolved and it can be an aid in the selection process. Qualitative data is images or text providing the basic choices to interpret the meaning their expressing, whereas quantitative data is numbers providing objective measurements of observed events. A research approach incorporating both qualitative and quantitative data does not necessarily have to put the same emphasize on both. In this thesis the emphasize is to the qualitative interviews and the results of the interviews are in a way controlled by the quantitative data of the sensory analysis (Denscombe, 2009).

## **3.2 Research methods**

### **3.2.1 Semi-structured interview**

The purpose of a semi-structured interview is to discover and identify the capacity and nature of the work of the person being interviewed (Patel and Davidson, 2011). The interviewer has a list of themes to be discussed and questions to be answered at a semi-structured interview, but is flexible when it comes to the order of the questions and letting the interviewee develop his or her ideas and speak more freely about the themes. Emphasize is on the opinions of the interviewee (Denscombe, 2009). The researcher can put together themes to be discussed or questions, however, the interviewee has great freedom in formulating the answers with their own words (Patel and Davidson, 2011). In this project, semi-structured interviews were preferred instead of structured interviews since the researcher will have the possibility of obtaining knowledge about the interviewees' perceptions with the possibility of asking follow-up questions depending on the answers. Semi-structured interviews demands entry knowledge from the researcher (Kvale and Brinkmann, 2009). Several interview questions can investigate one research question, hence by approaching a topic from several angles

gaining rich and varied information. Furthermore more than one research question can be answered through one interview question (Kvale and Brinkmann, 2009).

The interviews were conducted between 12<sup>th</sup> of March until 14<sup>th</sup> of April 2014 at the vineyards of the winegrowers and the offices or homes of the experts. One interview was conducted via *Skype* due to the location of the interviewee being too far away. Two interviews were conducted via email due to a busy schedule of the interviewees. The interviews lasted approximately 20 to 40 minutes and were guided by an interview guide (Appendix 5-7) prepared in advance. The interviews were audio recorded and transcribed, except for the interview conducted via email.

The questions of the interview were designed for two groups, the growers/winemakers and the experts. The purpose of the two groups was to get the opinion of the growers/winemakers but also the opinion of the experts that has followed the development of the wine sector in Sweden. A literature study was conducted to gain knowledge on the topic and inspiration for interview questions. It can be problematic to control the validity of interviews when they are regarding the interviewees' perceptions, feelings, and, experiences. Although it is possible to allow the interviewee to read the transcribed interview to control its accuracy, a way of ensuring that facts are correct (Denscombe, 2009).

### **3.2.2 Sensory analysis**

Sensory evaluation is carried out every day, our senses evaluate and approve anything we buy, eat or drink. However, a sensory analysis is a systematic way of measuring humans experiences of given stimuli to gain knowledge of how a person experiences a product or a samples sensory characteristics. A sensory analysis is performed by a chosen and trained panel with similar abilities to describe samples differences and/or characteristic and their intensity compared to a consumer panel which should not be trained. An analytical panel should not know why the analysis is taking place, or have too high knowledge of the product and be able to identify it even though its identity has been hidden. Finding products accepted by the consumer is the main goal of sensory measurements in the food industry (Hermansson, 1999).

Sensory methods can be divided into two main groups, analytical tests and consumer tests, an analytical test was used in this study. Furthermore analytical tests can be divided into two subgroups depending on if they are investigating the differences or describing the samples. Usually there is first a test of differences detect that there is in fact a difference between the

samples followed by a descriptive test to describe what the differences are and how big they are. The sensory analysis in this study was an analytical test with focus towards a descriptive test. The method applied when conducting a descriptive test is to first make a list of sensory characteristics that will vary between a few of the samples of the product, in this case white wine, and in addition construct scales to measure their intensities and finally perform assessments according to the developed form (Lundgren, 1981). Descriptive sensory analysis allows the researcher to obtain complete sensory descriptions of products, to identify underlying ingredient and process variables, and/or to determine which sensory attributes are important to acceptance (Lawless and Heymann, 2010). To conduct a sensory analysis a long experience is necessary, meaning it should be a specialist of sensory methodology and not a specialist of the product, the production, perceiving sensory differences of the product or the market of the product (Lundgren, 1981).

The sensory analysis was conducted by *Ipsos* at Krinova in Kristianstad, Sweden between April 22<sup>nd</sup> and May 2<sup>nd</sup> 2014. 8 panellists trained in sensory analysis conducted the analysis. The panellists were furthermore trained with the use of reference standards to understand and agree on the meaning of attributes used for analyzing white wine (Lawless and Heymann, 2010). The profiling was conducted in three steps; first a list of sensory attributes for white wine was created, secondly the panel was trained in assessing the wine and the attributes, finally the wines were blind tested in triplicate. As seen in photo 1 the wine is being poured from one side and handed to the panellists through the shutters and as seen in photo 2 the panellists are seated in individual booths to not be influenced of reactions from fellow panellists.



**Photo 1. The wine was poured on one side and handed to the panelists through the shutter. Photo: Julia Lindén**



**Photo 2. Showing four out of eight panellists performing the sensory analysis. The panellists were seated in booths so they were not be able to notice reactions from fellow panellists that could impact their decisions. The placed their answers on scales on the computer. The panellists are unaware why the sensory analysis is being made. Photo: Julia Lindén**

## 3.3 Data collection

### 3.3.1 Choice of research field

The purpose of this thesis is to be used as guidance to further development of Swedish production of wine. The production of grapes for vinification is established on a smaller area in Sweden, although increasing every year. By studying regions more experienced in grape growing and winemaking of similar climate as the southern parts of Sweden and comparing, gaps in knowledge in the production, market and consumption perspectives can be designated.

### 3.3.2 Sample size

When the purpose of an interview study is to investigate and describe in detail the interviewees' attitude towards something, interviews can be performed until a saturation point is reached and additional interviews would add little new knowledge. It is common the amount of interviews is between  $15 \pm 10$ , but can vary depending on the time and resources available (Kvale, 1997). Although saturation was obtained for several parts of the interviews the collection of data had to be finished due to lack of time. 15 winegrowers in Sweden and Denmark were contacted and seven agreed to an interview, seen in table 4. Seven wine experts were contacted and five agreed to an interview, seen in table 5. Four white wines of the Solaris grape were used in the sensory analysis, seen in table 3.

Table 2. Presenting the coding of the wines, grape variety and year of harvest.

	Grape	Year of harvest
W1	Solaris	2012
W2	Solaris	2013
W3	Solaris	2012
W4	Solaris	2013

### 3.3.3 Sampling technique for the interviews

The criteria in this study was that the vineyards were located in Scandinavia and of considerable production capacity (0,7 - > 1 ha) and the wine experts to have some experience of growing wine in a cool climate or experience of the sensory characteristics of Nordic wine. The vineyards are some well established and some recently established. Due to the small-scale of the Swedish vineyards it is normally the same person managing the work in the vineyard and in the wine cellar. The main source of identification of vineyards was through the members list on the website of the association *Svenska Vinodlare* (Svenska Vinodlare,

2014a) and an issue of the magazine *Världens Viner* (Världens Viner, 2013) with reportage on Swedish vineyards. The wine experts were found through reports, magazines and suggestions. Six interviewed wine producers were male and one female and out of the wine experts' one was female and four were male. The interviewed wine producers were in the age between 47 and 78 years.

**Table 3. Presenting the coding of the wine producer interviewees and information of the vineyards. Information obtained from the interviews.**

<b>Wine producer code</b>	<b>Position of the person interviewed</b>	<b>Location of vineyard</b>	<b>Vineyard area (ha)</b>	<b>Vineyard established</b>
<b>WP 1</b>	Grower and winemaker	Southeast Skåne	0,5	2000
<b>WP 2</b>	Grower	East Skåne	2	2011
<b>WP 3</b>	Grower and winemaker	Northern Zealand (Denmark)	0,7	1998
<b>WP 4</b>	Winemaker	Northeast Skåne	1	2004
<b>WP 5</b>	Grower and winemaker	West Skåne	1	2001
<b>WP 6</b>	Owner, grower	South Skåne	3,5	2003
<b>WP 7</b>	Owner, grower	Öland	1,4	2001

**Table 4. Presenting the coding of the wine expert interviewees and their occupations. Information obtained from the interviews.**

<b>Wine expert code</b>	<b>Occupation</b>
<b>WE 1</b>	Wine journalist
<b>WE 2</b>	Food science researcher
<b>WE 3</b>	German wine producer and consultant to Danish wine producers
<b>WE 4</b>	Buyer at <i>Systembolaget</i>
<b>WE 5</b>	Professor of Plant Science and wine producer

### 3.3 Data analysis

#### 3.3.1 Interview analysis

The interviews were recorded and afterwards thoroughly transcribed, and the transcribed interviews served as the raw data. Numbers were used to code the data to connect it with an idea, the numbers were then categorized and themes and connections between codes and categories could be identified. General conclusions based on connections, patterns and themes identified were made possible. These general conclusions can be in forms of concepts or hypothesis (Denscombe, 2009). The interviews of the two groups were analyzed individually and separate themes were established, however, some themes occurred with both groups. In the discussion it was possible to compare the opinions of the two groups.

### **3.3.2 Analysis of the results of the sensory analysis**

Spider charts are an easy and fast way of displaying differences between samples. They are constructed so that there is one axis for each attribute with the lowest intensity towards the middle and each sample's averages are connected with lines. There does not have to be a specific order of the attributes. By arranging the attributes with higher values to one side and the ones with lower values to the other side a figure will be created which serves the purpose namely to give a easily read overview of the differences between the samples (Lundgren, 1981). PCA (Principal component analysis) is a multivariate technique that describes and simplifies interrelationships among multiple dependent variables (these are usually the descriptors in sensory data) and among objects (these are usually the products in sensory data) (Anderson, 2003, Tabachnik and Fidell, 2006, Lawless and Heymann, 2010). Mean data for products across panellists and replications was used in the analysis of the results, PCA should be used on mean data which is why it was chosen as the appropriate technique (Lawless and Heymann, 2010).

### **3.4 Reliability and validity**

More interviewees could obviously have been included in the study to give a more trustworthy result, however, the decision was made together with the supervisor and assistant supervisor that it was a manageable amount of interviews for a master's thesis. The availability of including more white wines in the sensory analysis was possible, but it was difficult obtaining wines since some wine producers had sold out last their wine and not yet bottled the new wine and due to a limited budget it was not possibility to purchase wines.

With the research strategy 'mixed methods' it is possible that the time and costs could increase and there is no certainty that the different methods confirms each other (Denscombe, 2009).

## 4 Results

*This chapter presents the results from the study. The results from the interview with the wine producers are first presented according to the themes identified from the interviews followed by the results from the interviews with the wine experts. Finally the results from the sensory analysis are presented in spider charts.*

### 4.1 Wine producers

The backgrounds of the wine producers vary, however, none have a background an education in viticulture or oenology. Their knowledge is based upon self-studies, courses, travels to established vineyards or working at vineyards. Contact and exchange of knowledge with nearby wine producers is emphasized in the interviews. WP1 and WP3 conduct the work in the vineyard and in the winery on their own, WP4 is responsible for the work in the winery and has a partner who is responsible for the work in the vineyard, WP5 is both grower and wine maker but will hire qualified people if needed both in the vineyard and the winery, WP6 and WP7 both have personnel who is responsible for the winery, and the grapes of WP2 are processed into wine at a winery not in connection with the vineyard.

#### *Wine style*

The interviewed wine producers have in common that their red and rosé wines are usually blends and the whites are varietal wines. WP4 states that so far their white wine has been varietal but they will start to make blends of the white wine as well. At the moment WP2 produces varietal white wines, yet thinks it will be beneficial in the future to make two different white wines. Also WP6 is in the initial phase of developing a white sparkling wine and will for that blend grape varieties. Five out of six wine producers growing blue grapes say that they produce rosé wine, but originally the intention was to make red wine out of the grapes.

All interviewed wine producers have chaptalization (addition of sugar to reach the desired alcohol level) as method to apply in case the sugar content in the grapes is not satisfactory; however, it is a more common method when producing red wine. When making red wine WP6 applies chaptalization, but for every year the grapes reaches a higher sugar content and less chaptalization is used, and it is not necessary to use chaptalization for the white wine made from Solaris. With the Swedish climatic conditions WP5 means that high alcohol wine (14 – 15%) is necessary to balance the acidity natural to the climate, although it is always

appreciated if a good quality wine with lower alcohol can be made. A strategy applied by WP1 is to sell the wine under a different name the years when no chaptalization has been used. WP3 stresses the importance of physiologically mature grapes to avoid the use of chaptalization and also to make malic acid less of a problem. The malic acid is not viewed as a problem by WP6 either who rather sees it as an ingredient in the white wine and remove it through malolactic fermentation completely in the red wine.

WP3 produces only white wine, however, is planning to perhaps experiment with making sparkling wine. All the other interviewed producers make both white and rosé wines, some also produce red wine every year and some only make red when the season allows it, since the grapes need to be perfectly ripe to make a good quality red. WP5 reflects over the size and the experience of the vineyards in the rest of the wine world that produce more than two wine styles.

Our role, as winemakers in a climate zone on the border to what is possible can never be to contribute with several litres of wine to satisfy the need but to add supplementary flavours to the already rich taste palette of wine. WP6

Fruitiness is an important feature to bring out in the wine of WP1 and therefore no form of oak is used in the vinification process for neither red nor white wine of grapes such as Rondo and Solaris. The two grapes Rondo and Solaris are the most common grapes grown in the vineyards of the wine producers interviewed in this study, however, everyone has few plants up to a few rows of varieties they find interesting. Newly established WP2 aims to produce white wine fermented in steel tanks to create a dry, fresh and mildly aromatic wine. In addition WP3 describes the white wine of the vineyard as dry, aromatic, fruity and powerful from grapes such as Madeleine Angevine, Ortega and Solaris. The Solaris wine of WP4 is described as having characteristics such as mineral, citrus and elderflower notes, high acidity and with a subtle aroma. WP6 also describes the Solaris wine as being fresh with a high acidity, elderflower notes and also with a sweet finish. The wine is fermented on oak at WP5 creating rich white wine from the Solaris grape with a fresh citrusy acidity. Dark coloured wine is obtained due to the character of the soil and the climate according to WP7.

### ***Vision of the vineyard and wine***

Both WP1 and WP6 only wanted to produce wine that they wanted to consume themselves and the wine that they produce today exceeds their expectations. WP2 claims that it is difficult to have a vision of what wine to produce as there are few varieties to choose from

when it comes to suitability for the climate. Being a newly established vineyard WP2 even though has the vision to produce a good quality Swedish wine

There is the possibility of buying an imported wine with a better price. But the Swedish wine has its characteristics and we are not ashamed of it. As I always say, if it is not of good quality I will not bottle it I will pour it out. WP2

Since WP4 preferred red wine the majority of vines initially planted were with blue grapes to produce red wine. By researching the market WP5 found that more red wine was sold on the Swedish market and therefore planted more blue grapes than white. Today both WP4 and WP5 have shifted their visions as the blue grapes do not ripen as well as the white and vines with blue grapes have been removed in favour of white grapes. Conversely, WP3 had the vision to produce white wine from the beginning. WP4 has the vision to focus on quality both in the vineyard and in the winery.

Chemical analyses of the wines are made in the winery of all wine producers for parameters such as sugar, acidity, and so on. For more detailed analyses WP1 sends the wine to a colleague in Denmark with access to a FOSS WineScan machine. WP3 sends the wine for chemical analysing in an authorized laboratory in Germany. Throughout the vinification process the wine producers usually taste the wine and evaluate the quality of it, WP7 says through these evaluations it is decided together with a hired winemaker how to proceed in the vinification process and also the date when the wine can be sold. WP3 suggests that it is beneficial to allow an outsider to sensory evaluate the wine since it might be difficult to detect minor faults in the wine on your own.

### ***Tourism and consumers***

The newly established vineyard of WP2 already has requests for tours but claims it is too soon for visits and tours, however, thinks that in the future it could be interesting to have tastings together with one or more other vineyards. WP1, WP3 and WP7 offer tours, tastings can also be included in the tours, although special permission has to be sought to be allowed to offer tastings in Sweden. WP1 states arranging 60-70 tasting per year. Guided tours used to be offered to the public and tourists by WP4 but it has now proceeded towards only offering tours to companies and conferences, yet for a few occasions there will be tastings where anyone can attend. There could be more tourist events according to WP5 but it has not been their focus point. Tasting the wine where it has been grown and hear the story of the wine creates an experience which creates a storytelling effect according to WP6 and the wine can

be experienced during the summer by anyone at their restaurant together with locally produced flavour carriers and delicacies.

The question “which customer do you address”, received many different answers. Both WP5 and WP6 say that they address people who are interested in wine but for two different reasons, WP5 think that it is due to the price of the wine that only people interested in wine are attracted and WP6 think it is interested people because they would be attracted to enriching their taste palate. WP2 says that the customer is someone who thinks it would be fun to taste Swedish wine. WP1 identifies the customers as *Systembolaget* and restaurants and for WP7 it is currently *Systembolaget* but as the production increases WP7 would like to aim more towards restaurants. No marketing has been made by WP3, who cannot point out a specific customer but rather relies on the phenomena of storytelling.

### ***The future of the Swedish wine sector according to wine producers***

Not having the permission to sell the wine at the vineyard or winery is a hindrance according to most of the wine producers interviewed. WP7 thinks that selling the wine on the farm would contribute to new opportunities in terms of activities and visits, also WP2 think that being able to sell the wine on the farm would contribute to the atmosphere with visitors on the farm. However, WP2 also point out how fantastic *Systembolaget* is with its unique, high-quality assortment, but vineyard tours might not be as popular in the long run if the tourists are not able to buy a bottle and bring home. The quality of the wine being sold is emphasized by WP7 stating that wine producers should not be so eager to release the wine for consumption if it is not good enough. The price of the Scandinavian wine has to improve according to WP3, otherwise it might be difficult to compete with wine from established wine regions once the Scandinavian wine has lost its newsworthiness. As pointed out before WP5 has changed the vision of the vineyard from focusing on what the market consumes the most and what wine style that can be well-made in the area. For the future of the Swedish wine sector it would be important, according to WP5, to sync with other branches such as restaurants, the academic world and wine journalists and hopes for the future that restaurants will be willing to serve Swedish wine and possibly find dishes that would go well with the Scandinavian wine.

Important opinion leaders on the wine market should take on the Swedish wine, start talking about them and judging them, but also using them. It is sommeliers, wine journalists, well renowned restaurants, they should start signalling that Swedish wine is something to take seriously, be curious about, it is something new. However, we the wine producers should also signal with a high

professionalism that we have an ambition to make interesting, good quality and exciting wines. This should go hand in hand. WP6

Both WP5 and WP6 is of the opinion that little is being made on the marketing side in the Swedish wine sector, which indicates the vast potential of the sector, says WP5, as their wine is selling without marketing. With quality increase of the wine more people will discover them and it will generate more consumers according to WP5. Additionally WP6 means that the wine sector have challenge in attracting young and well educated young people to become interested in wine in order to continue the development of a Swedish wine sector.

## **4.2 Wine experts**

Five wine experts were interviewed to get their opinion on Scandinavian wine today and in the future. They were of different background and nationality was either Swedish or German. Their occupations were; journalist, researcher, professor, buyer and wine and viticulture consultant. They had in common that they had been in contact with Scandinavian wine for some years and were able to see the journey that Swedish viticulture has made. WE4 confirms that the Swedish wines that are available in the assortment of *Systembolaget* are purchased by *Systembolaget* as an 'exclusive product' or are launched in the *Systembolaget* shops closest to the vineyard or winery. For this type of small-scale launches *Systembolaget* does not work with quotation inquires or blind tests as the usually do.

### ***Scandinavian wine style***

WE1, WE2 and WE3 agree that Scandinavia has a better potential for producing white wine than red wine. WE1 imagine it to reflect the climate and therefore be a white fresh and cool wine whereas WE2 thinks it should be acidic and with champagne flavour.

White wine has much more potential to make a very good quality and a very unique own style of northern light, crispy, elegant and fruity wines. WE3

It is also agreed between WE1, WE2, WE3 and WE5 that there should not be expectations to produce wine like in France or Germany but rather finding specific flavours different from the existing styles. WE3 states that Scandinavia, by the nature of the vine, should have the best preconditions to produce wine of light style. However, both WE1 and WE5 think that a disadvantage of Scandinavian wine is that they often lack body due to low sugar contents and therefore according to WE5 it is of importance to find the right balance between sugar and

acid. WE1 says that the wines are not complete yet but that Solaris is a fantastic grape variety with much potential. Single variety wines are usually preferred by Scandinavian wine producers according to WE3 but blending could be beneficial for the future to get a broader variation of styles. People interested in wine are considered to be the customer most likely to purchase a Scandinavian wine according to WE1, WE3 and WE5 and WE1 and WE5 also states that the consumer they have in mind probably has a high income. WE2 thinks that the most likely customers are restaurants and WE4 confirms that the Swedish customer does buy wine produced in Sweden. WE1 believes that white wine with high acidity is often preferred by professionals in the wine business and that the soul of the wine is in the acidity, however, the Scandinavian wines are not complete yet. Red wine is difficult to produce in Scandinavia, but not impossible says WE3 and WE2 think that with better knowledge a better quality red wine could be created but for now rosé wine is more suitable.

### ***Tourism***

The same opinion is shared between WE1, WE2, WE3 and WE5 that tourism is very important for the vineyard. By visiting the vineyard, meeting the grower, the wine producer, or someone working in connection with the production storytelling is created and WE2 thinks that the storytelling could be enhanced if one could buy a bottle on the farm and bring home but also thinks that as a consumer can on their own see and confirm the traceability of the product. If the product has a high price it is important to see the people and hear the story to increase the possibility of selling the product says WE5 and WE3 agrees that if it is new and exclusive it is important to meet the winemaker, WE5 believes it is essential to explain to the consumer what is being done at the vineyard. Vineyard tourism is normal in other wine regions and WE3 consider it to be positive in this early stage of development.

### ***Expert quality ratings***

It could be helpful in today's situation to have a sticker confirming success in a wine competition on the bottle for example says WE3, while WE1 believes that it is an incentive for the producers to receive medals but think that wines must be judged only with wines from the same latitude. WE2 thinks that if a system was developed it should include both analytical and sensory evaluations and suggests that in Canada there is a good system. An approval system would be more beneficial according to WE5 as there are few producers and few wines and only certification that the wine is of good quality is sufficient.

### *The future of the Swedish wine sector according to the wine experts*

Since there is a trend towards locally produced products WE1 thinks that there is a future in a Swedish wine sector. WE4 confirms that many customers are interested in locally produced, small scale and handcrafted products.

The advantage of a regional product of the North is that first it is a regional product and a second aspect is that this regional product should have a taste which is accepted, which people like. WE5

The quality of the wine have to be steadier and thereby be able to lower the price a little and WE2 agrees with WE1 that the quality needs to improve. WE3 believes that there has to be more Scandinavian wine available for the consumers to convince them, there has to be a sustainable good yield on the existing fields of vineyards to survive economically not to create mass production. Scandinavian wine is a wine for touristic purposes or to be consumed on special events, not as a table wine says WE5. A meal should be designed to go well with the Swedish wine WE2 says.

With a typically Swedish environment in the restaurant with Swedish porcelain, Swedish cutlery, which I would say is designed well, where the entirety can be sensed, the wine together with the Swedish food, that is where the Swedish wine should be used. WE2

The Swedish wine is being sold at the three *Systembolaget* closest to the production site says WE4 and personally would like to see more suggestions of wines to get a wider distribution of the wine throughout the country. Although WE1 and WE5 think it is important for the future of the Swedish wine sector to be allowed to sell the wine on the farm, WE5 means it is important to sell in the moment otherwise the consumer might change their mind and not want to purchase. WE2 stresses the question of how to get young and hungry people into the Swedish wine sector and create a real branch with job opportunities in order to secure the future of the sector, also WE1 wonders who will take on the production in the future. There is also a knowledge gap to fill in the early stages of the production, WE2 says and wonders if the grapes that are the most suitable for Swedish climate do not exist just yet.

## **4.3 Sensory profile**

Spider charts show the results of the sensory analysis in terms of aroma, taste and aftertaste and mouthfeel and other of the white wines of the grape variety Solaris. The spider charts are

arranged in such a way that the attributes with the highest scores are placed towards one side to visually display towards which attributes the wine is drawn. Descriptions of the attributes are found in Appendix 9. Significant differences were found between the samples in the attributes aroma intensity, citrus, fruitiness, barrel and tropical fruits as shown in figure 1. The aroma profile of W1 and W4 follow each other relatively well except for the attributes mineral and oak where W1 have the highest values out of all samples. W2 has the highest intensity in the fruity and flowery attributes. Low values are found with W3 through all attributes except for sweetness and honey where it has high values together with W2. W2 and W3 are from the same wine producer but W2 is harvested in 2013 and W3 is harvested in 2012. Out of all samples W2 had the highest values in the attributes fruity, flowery, elderflower and tropical fruits.

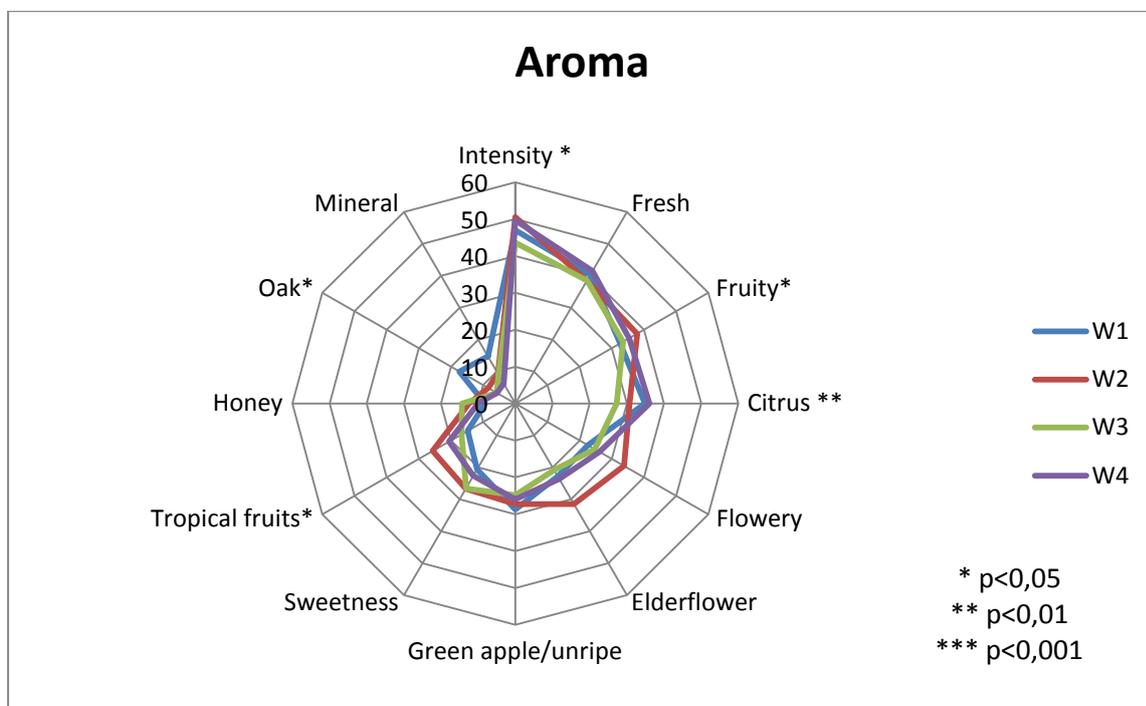
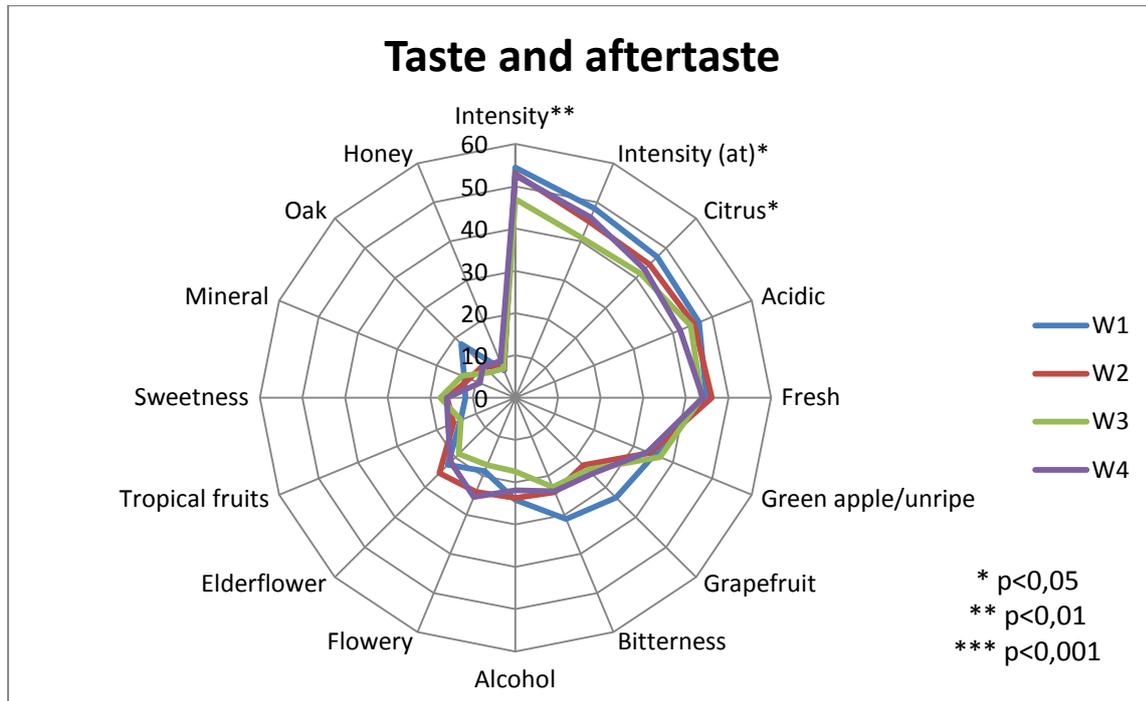


Figure 1. The aroma profile of the wines, on a scale from 0 to 100. There are significant differences between the samples in the attributes aroma intensity, citrus, fruitiness, oak and tropical fruits. The aroma profile of W1 and W4 follow each other relatively well except for the attributes mineral and oak where W1 have the highest values out of all samples. W2 has the highest intensity in the fruity and flowery attributes. Low values are found with W3 through all attributes except for sweetness and honey where it has high values together with W2. W2 and W3 are from the same wine producer but W2 is harvested in 2013 and W3 is harvested in 2012. Out of all samples W2 had the highest values in the attributes fruity, flowery, elderflower and tropical fruits.

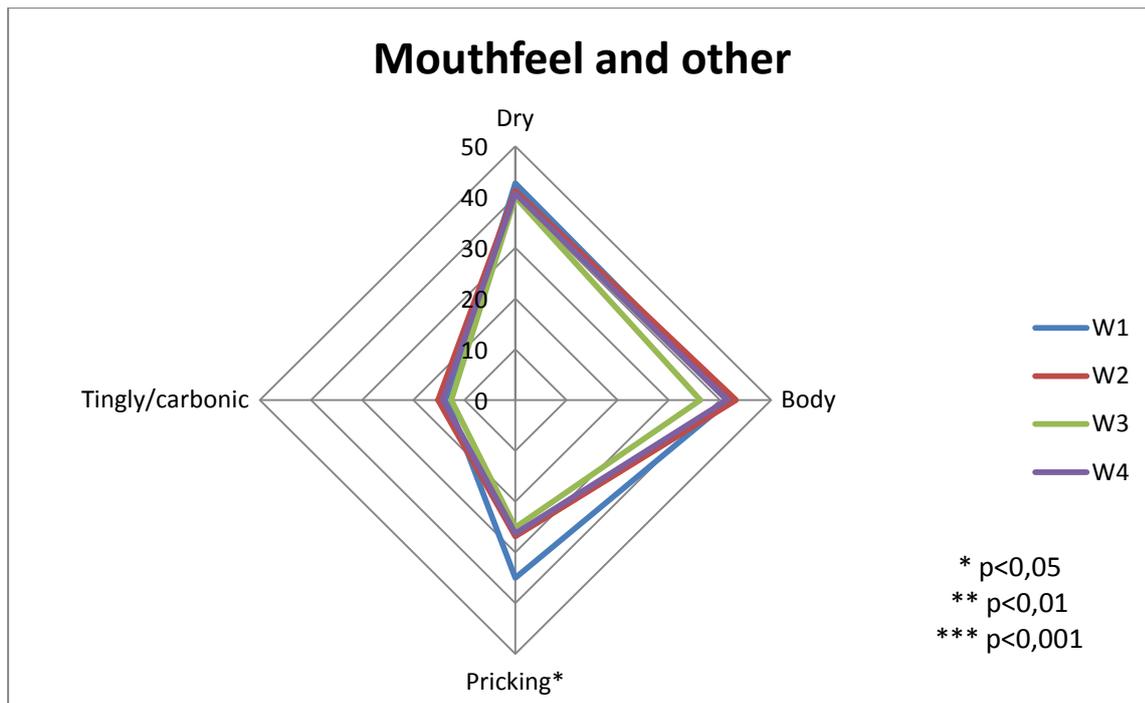
A significant difference between the samples in the attributes intensity of taste, citrus and the intensity/length of the aftertaste were found, seen in figure 2. W1 had the highest values in the attributes intensity of taste, bitterness, grapefruit and oak and its aftertaste lasts the longest and thus stands out from the group. W3 has the lowest values except for mineral, sweetness

and green apple/unripe throughout the attributes. Similar taste profiles are found for W2 and W4.



**Figure 2.** The taste and aftertaste profile of the wines, on a scale from 0 to 100. There is a significant difference between the samples in the attributes intensity of taste, citrus and the intensity/length of the aftertaste. W1 stand out from the group by having the highest values in the attributes intensity of taste, bitterness, grapefruit and oak and its aftertaste lasts the longest. Throughout the attributes W3 has the lowest values except for mineral, sweetness and green apple/unripe. Similar taste profiles are found for W2 and W4.

There is a significant difference between the samples in the prickling attribute and W1 has the highest value in that attribute. W3 has the lowest value for the attribute body otherwise the samples follow each other as seen in figure 3.



**Figure 3. The mouthfeel and other profile of the wines, on a scale from 0 to 100. There is a significant difference between the samples in the pricking attribute and W1 has the highest value in that attribute. W3 has the lowest value for the attribute body otherwise the samples follow each other.**

## 5 Discussion

*The results from the interviews will be discussed together with the results from the sensory analysis with regards to the research questions and the literature study in this section. Topics such as the microclimate, grape varieties, tourism, expert quality ratings, consumers, sensory profile of Swedish white wines and suggestions on future research will be discussed.*

### **The microclimate of Swedish vineyards is of great importance**

In the report by Eckersten et al. (2008) viticulture in any part of Sweden is displayed as almost impossible if only the HI is taken into account. Jackson and Cherry (1988) thought that calculating LTI was the most satisfactory to use when distinguishing the ripening capacity of grapes, however, pointing out that there can be irregularities. Irregularities are created by compensating for lacks in the regional climate with favourable microclimates such as south facing slopes and wind protection (Plocher and Parke, 2008). In 2013 the LTI for sites in Sweden varied between 40 and 78, as seen in Appendix 8. Jackson and Schuster (1987) placed grape varieties in groups (page 5) according to with which LTI they would ripen. Group A were the grape varieties that would ripen at LTI 190 and lower and was subcategorized into very cool and cool. Varieties such as Madeleine Angevine and Triomphe d'Alsace have the possibility to ripen in southern Sweden and were found in the category very cool. However, that particular grouping was made before the varieties Rondo and Solaris were available. Grape varieties has also been placed in groups according to their ripening capacity by Plocher and Parke (2008) where Rondo, Solaris and Leon Millot can be found in the group called 'tender'. By only looking at values obtained from calculations of HI or LTI viticulture on the latitudes of Sweden seems impossible, but when taking the ripening capacity of the grape varieties into account suddenly it seems possible. Microclimate therefore appears to have an extremely large impact on the success of a vineyard in Scandinavia, stressing the importance of choosing the site of the vineyard carefully. The LTI calculations also display that 2013 was a better year than 2012. In the sensory analysis, W2 and W3 were from the same wine producer, W2 being harvested in 2013 and W3 in 2012. As shown in figure 1-3 W3 had lower values than W2 for almost all attributes, also showing that 2013 was a better year than 2012. Focusing on the microclimate seems like a better approach for Swedish wine producers. In Appendix 2 parameters of acceptability for growing vines is displayed a useful guide when evaluating if a site is suitable for winemaking, which would be a useful list when evaluating a vineyard site. In that table the calculation of GDD is used and it is stated that it should be 850 or more. GDD for sites in Sweden is also calculated in

Appendix 2 and for a good season such as 2013 GDD some sites is above or close to 850. The table in Appendix 2 is created for England, a cool climate region such, and therefore might be more suitable to use as guideline.

The regional weather and climate should be assessed before choosing a growing site, afterwards it is possible to consider which grape varieties that could grow and fully ripen on that particular site (Plocher and Parke, 2008), although there are not a vast variety of cultivars to choose from as pointed out by WP2. Generally grape varieties cannot be planted just because they will ripen, some of the hardier varieties produce wines of poor quality and taste and would not appeal to the market (Gustafsson and Martensson, 2005). Since southern Sweden seems to be on the border of cool and cold climate for viticulture winegrowers are probably more likely to take a chance on a variety that almost certainly will fully ripen and deal with the seasons when it will not, rather than planting a variety that will give large yields every year but will produce a poor quality wine. *V. vinifera* is not sensitive to fluctuating winter temperatures common in southern Sweden, whereas for example *V. amurensis* and its hybrids are and interspecific hybrids can be anywhere in between (Plocher and Parke, 2008). Grape varieties from species that have evolved in very cold climates are probably not suitable for southern Sweden, *V. vinifera* should be the safest choice when considering winter hardiness in southern Sweden and interspecific hybrids should also be safe to avoid that the vine deacclimate too early. *V. amurensis* and its hybrids are probably more suitable in climates where there is a certainty of winter and no sudden warm spells. Spring frost is more of an issue in southern Sweden. Plocher and Parke (2008) then suggest varieties that begin growth late or have a slow growth rate following bud break. Yet again there might not be the possibility to choose between many varieties if there is a hope to produce a wine of good quality with a flavour that is accepted by the Swedish consumer.

### **Solaris and Rondo – the Nordic grape varieties**

Solaris and Rondo are the most popular grape varieties, but if the production increases will the wine producers be able to sell as many bottles as needed from the same grapes? WP2 also identifies too many bottles of the same variety as a possible problem in the future, especially if they are only being sold at the three *Systembolaget* closest to the vineyard. If the wine is sold by *Systembolaget* it is available throughout Sweden via ordering, but then the availability is reduced and the customers who will spontaneously buy a bottle ‘for fun’ or to try it might be lost. If that situation occurs it might be a beneficial tool to use blending to separate the wine in question from the main group as suggested by WE3. The sensory profile of this study,

however, shows that out of four white wines made from Solaris there are different aroma, taste, aftertaste and mouthfeel to the wines. A significant difference was only found for some of the attributes. Similar taste and aftertaste profiles for W2 and W4 were found but in terms of aroma W1 and W4 had a similar profile and W2 really stood out from the group.

Interestingly for both total intensity of aroma and total intensity of taste and aftertaste there was a significant difference between the samples, thus overall the wines are different to each other and therefore the fact that the vineyards grow the same varieties should not be a problem. Rather than focusing on the fact that the vineyards grow the same varieties it might be a good strategy to make people aware of the grape variety Solaris and the fact that it performs well in a Nordic climate and will create different sensory profiles for different sites.

The wine producers' initial vision of their wine production has shifted during the years, mostly due to the fact that the wine today is of better quality than they could ever expect and also that they have learned that the white grapes produce better wine than the blue. WE3 means that it is not impossible to produce red wine. Perhaps the vines need a few more years to mature before blue grapes suitable for red wine can be harvested and during that time producing rosé wine is a good way of getting an income.

The quality of the wine of a cool climate area will vary between the seasons, therefore some are labelled good vintages, some average, and some poor, a typical characteristic of a cool or cold climate region (Jackson and Schuster, 1987). This characteristic WP1 was aware of and consequently label the wines from seasons not in need of chaptalization differently from those with chaptalization. To achieve year-to-year consistency Plocher and Parke (2008) suggest blending as a suitable tool and also that varietal wines are not suitable for northern climates. However, the wine producers interviewed in this study all produce varietal white wines and often blend the red wine. Perhaps white grapes thrive more and fully ripen and therefore produce wine good enough to make a varietal wine, whereas the blue grapes do not thrive and the wine produced is not complete and therefore blending is necessary. WE3 says that varietal wines are preferred in Scandinavian. This is probably because there are few varieties available producing good quality grapes in this climate and also since the wine production in Sweden is young and it might be a strategy to first be good at producing a good quality varietal wine before expanding to blending.

A good knowledge of the grape variety when planting the vines appears to be of great importance. Some varieties can lack varietal flavours at 19 °Brix while some varieties can

produce an acceptable wine at the same sugar content (Plocher and Parke, 2008). The sugar content is the most commonly used harvest indicator. However, furthermore proving the importance of knowledge of the particular variety, if monoterpenes is an important ingredient in the wine sugar content is not the most suitable harvest indicator as monoterpenes continue to increase after sugar accumulation has slowed down (Park et al., 1991). Much attention should therefore be put to the specific variety grown and where does the desired characteristics in the finished wine derive from?

### **Tourism and expert quality ratings**

In Canada tasting rooms at the vineyards or wineries have been a great help to increase sales since the wineries are far away from each other, small-scale and with low export-rates (Doloreux and Lord-Tarte, 2012). Tasting rooms are most likely also a good help for Swedish vineyards or wineries, however, it is probably even more necessary that the tasting is accompanied by a touristic event such as a guided tour in the vineyard or a lecture to increase the likelihood that they participants will later on purchase the wine via *Systembolaget* and therefore more work has to be put into the business than just establishing a tasting room in Sweden. Several studies show that expert quality rating could be of even more importance in cool climate regions because the wines are from lesser known regions and producers (Troncoso and Aguirre, 2006, San Martin et al., 2008, Schamel, 2009, Schroeter et al., 2011). However, an expert's opinion does not guarantee that a consumer will have the same experience. There could be a risk of only presenting expert ratings, but accompanied with a consumer test there might be a better chance of reaching the consumers only interested if the wine taste good or not according to their palate, although this depends on whether the wine producer wants to sell to experts such as restaurants or to consumers. Which palate do they want to attract? It could be helpful in the winemaking process to know which consumer they are aiming at.

### **What consumer does the vineyard address?**

The question 'what customer do you address' was asked in the interviews with the wine producers and different answers were received. Naturally the answers varied because of different interpretations of the question. All wine producers in Sweden must consider *Systembolaget* as the main customer but it was interesting to see if the wine producers have thought about who will buy it from the selves at *Systembolaget*. In common, however, is that little marketing is being made by the wine producers, information on the vineyards is mainly through articles in newspapers, magazines or websites of associations such as *Svenska*

*Vinodlare* or the vineyard's own website. Generally it might then be more common that the customers search for the information and then not surprisingly the most likely customer is someone interested in wine, which is the group that some of the wine producers point out as the customers that they address. It is possible if the aim is to attract a person interested in wine, at the same time well renowned restaurants will be attracted. However, if the main purpose of producing wine is to sell it at *Systembolaget* rather than to restaurants it might be necessary to have a different approach in the wine making process. Furthermore, a person interested in wine could be many different people, it could be someone interested in, as WP6 says, enriching the palette and sense the different flavours of the wine, it could be someone who enjoys wine very much but is only interested in if it taste good or not and in this case it could also be someone who is interested in products locally produced. WE1 thinks it is because of the trend towards locally produced products that there is a future in Swedish viticulture.

In terms of tourism in connection with the winery WE1, WE2, WE3 and WE5 all agree that it is very beneficial if the customer can visit the vineyard and meet the wine producer or someone working in connection with the vineyard or winery. Different types of touristic events are arranged by all wine producers in varying frequency, however, some state that it takes too much time from the vineyard and wine making and some only arrange event for companies and conferences etc. Could it be that the benefits from arranging touristic events are not as great when the visitors are not able to purchase the wine then and there and therefore the wine producers are less inclined to arranging them, or might it be that the wine is sold even without touristic events? WE5 points out the fantastic potential that the Swedish wine sector has since people are buying the wine even without marketing. There is a possibility that a wine producer arranging touristic events does not sell the wine at *Systembolaget* but is able to make the visitors interested and later on they will purchase the wine found on the shelves at *Systembolaget*. Even though the wine producers hope that they will be allowed to sell their wine at the vineyard or winery perhaps they will reach more and also unexpected customers through *Systembolaget*, however, many think that it would contribute to a nice atmosphere at the vineyard if people could come there and purchase the wine.

### **Sensory profile of Swedish white wines**

The wine producers have good knowledge of the sensory profile of white wine from southern Sweden and Denmark. Elderflower, citrus, mineral, high acidity, fruity, dry and sweetness are

attributes found in the wines from the sensory analysis of this study as seen in figure 1-3. Figure 3 describes mouthfeel and other attributes and shows that they are all dry which is identified by WE1, WE2, WE3 and WE5 to be what they imagine a good quality Scandinavian wine to be. Both WE1 and WE5 claim that the Scandinavian wines often lack body. The attribute body is included in figure 3, however, it cannot be concluded if that level of body is satisfactory or not, a consumer test would be needed for that. The spider chart of the aroma, seen in figure 1, shows a more attractive picture of the wines since desired attributes such as fruity and elderflower has higher levels than green apple compared to the spider chart for the taste, figure 2. Possibly showing that more emphasis should be put to increasing the quality of the taste as the aroma is already there, however, it might be very pleasant to have an intense aroma followed by a slightly acidic taste. Are the attributes found in the sensory analysis the attributes that are wanted by the consumer though? WE5 says that a regional product should have an accepted taste which people like. There is no tradition of wine making in Sweden and therefore it is difficult to know what the accepted taste is. It is very important to know that wine making in Sweden is very young and without tradition. This means that there should be an understanding that the Swedish wine improves every year, WP6 for example says that they are still in a developing phase, and WE1 also says that the Swedish wines are not complete yet. A consumer that has tasted Swedish wine once and not liked it might have a negative view upon it and is reluctant to buy another bottle even though several years have passed. Perhaps this was in the early years when more red wine was produced in Sweden, before it was realized that white wine or rosé wine is more suitable? The wine producers should somehow show that they are making improvements. As mentioned by WP5 usually the vineyards that produce several wine styles are very big. It would probably be easier to increase the quality of the wine if a Swedish wine producer would focus on one style, although since the wine sector is so young it is probably inevitable that the wine producers want to experiment with different wine styles to find the most suitable for their particular site.

### **Suggested future improvements of the Swedish wine sector**

Chemical analyses of the wines are carried out continuously by all wine producers. However, sensory analyses are only sometimes conducted and mostly by the wine producers themselves to evaluate the progress of the vinification process. WE5 suggests that if a type of rating systems should be applied in Sweden it should rather be an approval system than a system ranking the wines as there are quite few wine producers. An approval system could be

established with inspiration from the Canadian VQA system as suggested by WE2. This should be a good opportunity since *Systembolaget* does not perform blind tests on the Swedish wine that they sell. If the wine is approved it could be visible on the bottle with a sticker for example, signalling to the customers that the wine is of good quality and also signalling that improvements are being made and the Swedish wine sector is professional. The wine producers are probably also in need of help from sommeliers, wine journalists and well renowned restaurants as suggested by WP6 to spread the word that Swedish wine is interesting. Instead of marketing individual vineyards, perhaps emphasize could be put to marketing Solaris, a relatively new grape, but a grape thriving in Scandinavia to strengthen the image of Solaris as a grape producing wine with a enjoyable flavour. Most importantly in order to keep the Swedish wine business a sector of continued growth is to get young people interested by creating job opportunities. If job opportunities are created also the need for more education is created. Canada and England are examples of regions where wine growing is not a tradition but where the sector has grown it to such a business that higher education opportunities have been established.

## 6 Conclusions

How a white wine produced from grapes grown in Sweden should taste cannot be answered, but the sensory profile established in this study is a start. A consumer test would show if the flavour is accepted by consumers and would be a possible continuation of this study.

However, wine producers and wine experts overall seem to have the same opinion of how the white wine should taste. The sensory profile of white wine from grapes grown in Sweden is according to this study a wine with a fresh, citrus and flowery aroma and a fresh, citrus and green apple taste.

There is a great potential of good quality Swedish wine because of trends towards locally produced products, however, the future of the sector needs to be secured by creating job opportunities and education, suggested by both a wine producer and wine experts. Trends show that in countries such as Canada and England higher educations have been established to ensure progress of the wine sector.

Developing an approval system for Swedish wine based on chemical and sensory analysis is an opportunity to further mark that the wine producers are making progress, example of successful quality assurance systems can be found in Canada. An approval system could also be used as a sort of marketing strategy for the Swedish wine producers. According to some wine producers interviewed little or no marketing of their wine is being made and any type of marketing should therefore be beneficial.

It is difficult to trust calculations such as LTI for locations in Sweden, the right site with the right microclimate is of greater importance for successful wine grape growing. GDD calculations give a more fair result for locations in Sweden. In the interviews with the wine producers no questions were asked about the microclimate of the vineyards but it could also be of interest to further investigate the locations of Swedish vineyards.

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## Appendix 1: Grape varieties

### Red grape varieties

*Red grape varieties that are common in cold and cool climate areas, or with a possibility of ripening sufficiently in those climates*

<b>Rondo (interspecific)</b>	Rondo develops medium-sized berries and clusters, almost twice the size of Leon Millot. In a cool climate such as in Denmark with 750 – 850 DDC (Celsius degree days) Rondo ripens sufficiently for winemaking, reaching 18 °Brix and acidity around 1,0 to 1,1% in an average year. Rondo buds early in the spring and sets fruit well even in the worst of seasons for cold and rain. It is susceptible to winter injury due to its tendency to lose dormancy during periods of freezing and thawing. Because of this tendency, and its overall lack of winter hardiness, in cold winter areas it should be carefully protected. Even when less than fully ripe, Rondo will develop a good varietal flavour. The wine benefits from oak or blending to improve its complexity (Plocher and Parke, 2008).
<b>Marechal Foch (French-American hybrid)</b>	Marechal Foch was developed in Alsace, it produces medium-sized clusters with small to medium grapes. A significant amount of heat is required to fully mature the fruit. It can tolerate mid-winter as low as -32°C. For winemaking Marcheal Foch is very versatile, depending on the climate conditions it is possible to produce everything from pleasant rosé wine to red table wine suitable for aging if the grapes are fully ripe with 23 °Brix, pH of 3,3 and total acidity of 1,0% (Plocher and Parke, 2008).
<b>Leon Millot (interspecific)</b>	Leon Millot is a sister of Marechal Foch, ripening earlier. The grapes can develop an excellent balance of sugar and acidity for wine production. In areas with colder temperatures then -26°C Leon Millot is in need of winter protection (Plocher and Parke, 2008).
<b>Castel 19,637 (French-American hybrid)</b>	Castel 19,637 is a French-American hybrid, is has large clusters of rather small grapes. It has the potential of ripening up to 24 °Brix, even in very cool autumn weather is has the ability to continue to ripen and accumulate sugars and reduce acids, however, it has a tendency to develop rather high acidity. The disease resistance of Castel vines is outstanding and it has a high vigour, and in need of winter protection in cold winter areas. By conventional red wine techniques the wine produced from Castel is coloured and tannic, making it especially useful as a blending component with weaker red wines. Depending on the degree of ripeness the varietal flavours vary (Plocher and Parke, 2008).
<b>Frontenac (<i>V. riparia</i> hybrid)</b>	Frontenac was selected from a cross of <i>V. riparia</i> x Landot 4511. Moderately-loose medium to large clusters of medium-sized blue-black grapes are produced from Frontenac. It is a very productive vine and it can overproduce, therefore cluster-thinning is needed for the best quality grapes. The grapes mature rather late, in Minnesota in the last half of September. It will have high acidity if grown in insufficient heat or picked prematurely. It should not be harvested

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based only on sugar content because it has a tendency to drop precipitously in acidity at the end of the season long after sufficient sugar is developed. To all fungal diseases it has excellent resistant, except for Black Rot to which it is moderately susceptible. It is a hardy variety, able to withstand temperatures down to -35 °C. From fully ripen grapes Frontenac develops a cherry-like nose. Frontenac wines can have a pronounced *V. riparia* character but it can be reduce with different winemaking techniques such as shorter contact with the skins and using a yeast not emphasizing the varietal flavour (Plocher and Parke, 2008).

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### **White grape varieties**

*White grape varieties that are common in cold and cool climate areas, or with a possibility of ripening sufficiently in those climates.*

<b>Solaris (interspecific)</b>	The clusters of Solaris are medium-sized and the grapes ripen in the end of September, it is possible however, to leave the cluster longer to achieve higher sugar content. The wine has been described as flavoursome and fruity with hints of muscat, honey, and sometimes banana and hazelnut aromas (Gundersen and Génsbøl, 2007, Plocher and Parke, 2008).
<b>La Crescent (<i>V. riparia</i> hybrid)</b>	La Crescent was developed at University of Minnesota from a cross of St. Pepin x E.S. 6-8-25, is has long tightly formed clusters and is hardy down to -35 °C. Fully ripe berries usually produce a wine within the apricot flavour range, although sometimes with a hint of plastic or mineral (Plocher and Parke, 2008).
<b>Seyval Blanc (French-American hybrid)</b>	Seyval Blanc has large clusters and can be very productive, therefore cluster thinning is necessary. When the grapes are fully ripe a wine with good body, straw yellow colour, and an aroma resembling Chardonnay (Plocher and Parke, 2008). It is relatively winter hardy and tolerant to many soil types (Jackson, 2008).
<b>Madeleine Angevine (<i>V. vinifera</i> variety)</b>	The clusters developed by Madeleine Angevine can be rather large with small round berries. The sugar content rarely develops to a high level, thus the harvest date should be based upon aroma and acidity levels. The roots are sensitive to frost. Due to late bud burst it is not very sensitive to spring frost. The wine produced is fruity with flowery and muscat aromas (Gundersen and Génsbøl, 2007).
<b>Ortega (<i>V. vinifera</i> variety)</b>	Ortega is a cross between Müller-Thurgau and Siegerrebe. It has medium-sized clusters. If the weather is cold and wet during flowering the flowers will be poorly pollinated and small grapes without seeds will develop. It has a good winter hardiness for a <i>V. vinifera</i> variety and it is somewhat resistant to spring frost. The finished wine has muscat and peachy aromas (Gundersen and Génsbøl, 2007).

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## Appendix 2: Parameters of acceptability for growing vines

Table 5. Parameters of acceptability for growing vines (used with permission) (Foss et al., 2010).

Parameter	Acceptable	Not acceptable	Comments
<b>pH</b>	5-8	Less than 5; more than 8	High acidities are toxic to vine growth due to the high availability of copper and aluminium (Seguin, 1986).
<b>Depth to bedrock (cm)</b>	20+	Less than 20	Soils where root penetration is problematic due to shallowness are considered unsuitable for vine cultivation (Jackson, 2008).
<b>Soil drainage (mm/day)</b>	500+	Less than 500	Poor soil drainage excludes oxygen from the soil pores, which adversely affects grapevine nutrient assimilation (Wilson, 1998). Free-draining soils will also cause a mild stress during ripening, which improves grape quality (Smart and Robinson, 2001).
<b>Organic matter (%)</b>	1-10	Over 10	Excessively fertile soils will lead to excessive growth and dominance of vegetative over reproductive activity, leading to yield of low quality and quantity (Smart and Robinson, 2001).
<b>Growing degree days (°days)</b>	850+	Less than 850	This figure represents the sum of the temperature that a region gets above 10°C over the year, and is a clear indication of the region's potential for the vine to complete its annual growth cycle (Dry and Coombe, 2004).
<b>Total annual rainfall (San Martin et al.)</b>	450-850	Less than 450; more than 850	450 mm is regarded as the minimum level of rainfall required by an un-irrigated vine (Dry and Coombe, 2004), whereas high rainfall sites typically suffer from excessive vegetative growth (Dry and Coombe, 2004) and increased disease pressure (Smart and Robinson, 2001). Typical rainfall for French vinegrowing region is 680 mm (Wilson, 1998).
<b>Frost days during growing season (days)</b>	0-9	More than 9	Vines are very sensitive to frost during the growing season (Jackson, 2008), as this will kill all green shoots (Dry and Coombe, 2004) and cause extensive yield reduction (Wilson, 1998). Secondary shoots will grow, but these are over 60% less fruitful (Dry and Coombe, 2004).
<b>Average wind speed over growing season (knots)</b>	0-15	More than 15	Strong winds will increase drought stress on plants and cause reduced stomatal conductance on the leaves, thus reducing photosynthesis. This will affect both growth and yield (Dry and Coombe, 2004). Wind will also have cooling effect and can cause shoots and trellis damage (Dry and Coombe, 2004).
<b>Angle of</b>	0-45	Greater than	Sloping land will aid the drainage of cold air thus

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<b>slope (°)</b>		45	alleviating frost risk (Jackson, 2008, Dry and Coombe, 2004), but excessive slopes will hamper the use of machinery and render cultivation uneconomical.
<b>Elevation (m)</b>	0-250	More than 250	Mean site temperatures decrease by 5-6°C for every increase in 100m in elevation (Dry and Coombe, 2004) the negative effects of wind exposure.
<b>Aspect</b>	E-SE-S-SW	NE-N-NW-W	In northern latitudes, southern-facing slopes will gain solar radiation (Dry and Coombe, 2004), particularly during the ripening period, and reduce the lag phase during which a site heats up after a cold night (Jackson, 2008), thus increasing the potential for photosynthetic activity by the plant. Westerly aspects have the disadvantage of being more exposed to the dominant winds in the area.

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## Appendix 3: Invitation letter, Swedish

Hej!

Jag heter Julia Lindén. Jag läser till Hortonom vid SLU, Alnarp och är på mitt femte och sista år. Jag har under utbildningens gång intresserat mig för vinodling och – framställning och bl.a. läst kurser vid Köpenhamns Universitet med inriktning på vintillverkning i kalla klimat. Därför passar jag nu på att skriva mitt masterarbete (30 hp) med inriktning på just vin.

Jag ska göra en serie intervjuer och jag är intresserad av att intervjua dig. Det är en kortare intervju som kommer att fokusera på vingården, vintillverkningen och dina erfarenheter. Den kommer att spelas in för att kunna transkriberas och vara en del av mitt masterarbete. Det är frivilligt om du vill ställa upp med ditt namn och vingårdens namn eller om du vill vara anonym.

Syftet med arbetet är att studera smakupplevelser av nordiska viner och vad för trender som syns i andra regioner som producerar vin i kallt klimat som t.ex. Kanada. Är du intresserad av att ställa upp på en intervju?

Mvh

Julia Lindén, Hortonomstudent

## **Appendix 4: Invitation letter English**

Dear ...,

My name is Julia. I'm studying horticulture at SLU Alnarp, Sweden, at the moment I'm writing my master thesis on wine. I'm looking into cool climate viticulture, trying to find information from areas such as in Canada where viticulture is expanding, and see if it can be applied to the viticulture and enology in Sweden.

I'm interviewing growers/winemakers in Sweden trying to figure out how they want their wine to taste, what they are doing to achieve their vision and if they have the consumer opinion in interest. Trying to figure out the consumer interest I want to interview for example wine journalists, wine importers, etc. and hopefully also a representant from the Swedish alcohol monopoly company since they have to buy the wine before it can reach the final consumer.

I was wondering if I could interview you as an enologist with experience of Nordic wines? It will be a rather short interview and preferably via Skype as it is of importance for my thesis that the interview is made face to face, however, I'm short of time and unfortunately I cannot travel to Germany for the interview.

Regards,

Julia Lindén

## Appendix 5: Interview guide, winegrower

		Question
<b>Background</b>	1	Namn?
	2	Vad har du för bakgrund?
	3	Roll i företaget?
	4	Har du utbildat dig inom vinodling/tillverkning?
<b>About the vineyard</b>	5	Namn?
	6	Startår?
	7	Areal?
	8	Vilken/vilka sort/er odlas?
<b>Viticulture and Enology</b>	9	Vad för typ av vin tillverkas?
	10	Finns det planer på att producera andra typer av viner?
	11	Fanns det en vision om vad för typ av vin som skulle tillverkas vid etableringen av vinodlingen?
	12	Vilken är de viktigaste karaktärsdragen i ditt färdiga vin?
	13	Hur bedöms sensoriken i vinet?
	14	Tillämpar du kemiska analyser?
	15	Tillämpar du sensorisk bedömning?
	16	Söker du efter ny kunskap?
	17	I så fall var söker du?
	18	Hur bestäms skördedatum i din odling?
	19	Behöver du skydda dina vinrankor vid stränga vintrar?
	20	Har du problem med vårfrost?
	21	Har du problem med höstfrost?
	22	Har du någon åtgärd i odlingen för att hindra frosten?
	23	Har du bevattning i odlingen?
	24	Vilken kund riktar du dig till med dina viner?
	25	Tar du in hjälp till någon del av vinodlingen?
	26	Tar du in hjälp till någon del av vintillverkningen?
	27	Vad för jästkultur används?
	28	Vilken alkoholhalt siktar det på?
	29	Tillämpar du chaptalisering för att uppnå den alkoholhalten?
	30	Justeras syran i ditt vin?
	31	I så fall med vilken metod?
	32	Tillämpar du malolaktisk jäsning?
	33	Är äppelsyran ett problem i ditt vin?
	34	Gör ni vin av bara en sort eller blandas sorter?
	35	Hur hanterar du växtskyddsproblem i odlingen?
	36	Odlar du ekologiskt?
	37	Om inte, vill du vara ekologisk?
	38	Vilken är den viktigaste förändringen som krävs för att konsumtionen av svenskt vin ska öka?

## Appendix 6: Interview guide, wine expert

	Question
<b>Background</b>	1 Namn:
	2 Vad har du för bakgrund?
	3 Vad arbetar du med?
<b>Viticulture and Enology</b>	4 Hur tycker du att ett nordiskt vin ska smaka?
	5 Ur smak synvinkel, vilka fördelar har nordiska viner?
	6 Vilka är nordiska viners största nackdelar?
	7 Är lokalt producerat vin intressant när det gäller vin enligt dig?
	8 Är ekologiskt vin intressant?
	9 Vilket tror du att konsumenter väljer helst, lokalt producerat eller ekologiskt?
	10 Är det viktigt att ha möjlighet att se hur vinet det har odlats? (turism)
	11 Är det viktigt att ha möjlighet att träffa vinproducenten?
	12 Tror du det är viktigt med bevis på bedömning på flaskan för kunderna? T.ex. i form ett märke som talar om hög placering i tävlingar m.m.
	13 Är placering i sådana tävlingar ett korrekt sätt att visa på kvalitet?
	14 Vad anser ni om att chaptalisering (tillsats av socker för jäsning) används?
	15 Vad för trender finns för tillfället inom vin? T.ex. runt om i världen men som svenska vinodlare skulle kunna dra nytta av.
	16 Finns det trender inom druvor?
	17 I så fall kan du se någon trend som pågår nu?
	18 Pågår det trender inom produktionssätt just nu?
	19 Är de trenderna intressanta för nordisk vinodling?
	20 Vilka kunder tror du är intresserade av nordiska viner?
	21 Enligt Systembolaget ökar konsumtionen av vin med lägre alkoholhalt (<9,5%), kan svenska vinodlare dra nytta av trenden med viner med lägre alkoholhalt? T.ex. om druvorna inte uppnår tillräckligt hög sockerhalt men är smakmässigt mogna.
	22 Vilken är den viktigaste förändringen som krävs för att konsumtionen av svenskt vin ska öka?

## Appendix 7: Interview guide, wine expert, English

		Question
<b>Background</b>	1	Name?
	2	What do you do for a living?
	3	What is your background?
	4	What connection do you have to Scandinavian wine producers?
<b>Viticulture and</b>	5	If you imagine Scandinavian wine, how do you imagine it to taste?
<b>Enology</b>	6	Out of a sensory point of view, what advantages does Scandinavian wine have today?
	7	What disadvantages does Scandinavian wine have today?
	8	Is locally produced wine interesting for consumers?
	9	Is organic wine interesting for consumers?
	10	Which do you think is the most important for the consumer, locally produced or organic?
	11	Is it of importance to be able to visit the vineyard? (turism)
	12	Is it of importance to be able to meet the wine producer?
	13	For Scandinavian wine, do you think it is of importance with proof on the bottle that the wine has been judged by a professional panel?
	14	Is that type of labelling a correct way of showing quality?
	15	What is your opinion on chaptalization?
	16	Can you see any trends in wine at the moment?
	17	Can you see any trends in grape varieties?
	18	Can you see any trends in ways of producing wine?
	19	Are they interesting for Scandinavian wine production?
	20	What consumers do you think are interested in Scandinavian wine?
	21	According to <i>Systembolaget</i> consumption of low alcohol wines (<9,5%) is increasing, do you think that is a trend Scandinavian winemakers should take advantage of?
	22	What is the most important change necessary to increase the consumption of Scandinavian wine?

## Appendix 8: LTI calculations

LTI calculated for four locations in Sweden, Alnarp and Anderslöv in Skane, Torslunda on Oland and Visby on Gotland. GDD is with base temp 10°C and during the period 1<sup>st</sup> of May to 10<sup>th</sup> of October. Temperature data were found via FältForsk (FältForsk, 2014). Torslunda had no temperature record for 2011 and 2012 and the value for Anderslöv in 2013 did not seem accurate and is therefore not included.

2013	Latitude °N	MTWM (°)	LTI = MTWM (60 – latitude)	GDD
Alnarp	55,66	17,9 (July)	78	937
Anderslöv	55,44	17,1 (August)	78	-
Torslunda	56,64	17,6 (July)	59	807
Visby	57,64	17,1 (August)	40,4	261

2012	Latitude °N	MTMW (°)	LTI = MTWM (60 – latitude)	GDD
Alnarp	55,66	17,1 (July)	74	839
Anderslöv	55,44	16,4 (August)	75	604
Torslunda	56,64	-	-	-
Visby	57,64	17,0 (July)	40,2	232

2011	Latitude °N	MTMW (°)	LTI = MTWM (60 – latitude)	GDD
Alnarp	55,66	17,2 (July)	75	888
Anderslöv	55,44	16,6 (July)	76	618
Torslunda	56,64	-	-	-
Visby	57,64	18,2 (July)	43	284

## Appendix 9: Attributes in the sensory analysis

Description of the attributes used in the sensory analysis.

Attribute	Explanation
<b>Aroma</b>	Scale: (0-100) from nothing to much
<b>Intensity</b>	Total intensity of aroma
<b>Flowery</b>	Intensity of flowery aroma; a light perfumed, hyacinth, jasmine, lily of the valley, roses, violet, white flowers
<b>Citrus</b>	Intensity of citrus aroma; various citrus fruits such as lemon, lime, grapefruit and orange
<b>Elderflower</b>	Intensity of elderflower aroma
<b>Fresh</b>	Intensity of fresh aroma
<b>Fruity</b>	Intensity of fruity aroma
<b>Honey</b>	Intensity of honey aroma
<b>Oak</b>	Intensity of oak barrel characters in the aroma
<b>Mineral</b>	Intensity of minerals/limestone
<b>Sweetness</b>	Intensity of sweet aroma
<b>Tropical fruits</b>	Intensity of tropical fruits aroma such as mango, peach, pineapple etc.
<b>Apple green/unripe</b>	Intensity of a young and unripe apple
<b>Taste</b>	
<b>Intensity</b>	Total taste
<b>Bitterness</b>	Intensity of bitter taste
<b>Flowery</b>	Intensity of flowery taste; a light perfumed, hyacinth, jasmine, lily of the valley, roses, violet, white flowers
<b>Citrus</b>	Intensity of citrus taste; various citrus fruits such as lemon, lime, grapefruit and orange
<b>Alcohol</b>	Intensity of high perceived alcohol level in the wine
<b>Oak</b>	Intensity of oak barrel character
<b>Elderflower</b>	Intensity of elderflower taste
<b>Fresh</b>	Intensity of fresh taste
<b>Grapefruit</b>	Intensity of taste of grapefruit, high acidity and some bitterness
<b>Honey</b>	Intensity of honey taste
<b>Mineral</b>	Intensity of taste from minerals/limestone
<b>Acidic</b>	Intensity of acidic taste
<b>Sweetness</b>	Intensity of sweet taste
<b>Tropical fruits</b>	Intensity of taste from tropical fruits such as mango, peach, pineapple etc.

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<b>Aftertaste</b>	
<b>Intensity</b>	Intensity/length of the aftertaste
<b>Mouthfeel</b>	
<b>Tingly/carbonic</b>	Intensity of tingly, foamy and carbonic mouthfeel
<b>Pricking</b>	Intensity of a pricking mouthfeel
<b>Dry</b>	Intensity of a dry mouthfeel
<b>Other</b>	
<b>Body</b>	Intensity fo the body of the wine

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