

Quality Parameters In Wine Industry

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ABSTRACT

Today, there is a lot of alcoholic drink types. Red wine is also among these types of drinks. It is a highly preferred alcoholic drink that can be drunk in celebration of special days, as well as in meetings among friends in the evenings.[2] Looking at this, we can say that red wine is generally preferred at the end of the day to relieve stress. At the same time, if it is not drunk in excessive amounts, wine has many properties that are good for our health; such as preventing cancer, preventing Alzheimer disease, strengthening bone structure, preventing kidney stone formation, preventing blood coagulation, being anti-aging and protecting dental health [18]. Due to these benefits and the intense preference rate, it is of great importance that the wine preferred by the customer is of high quality. Therefore, in this study; what wine is, what are the suitable properties for a wine with quality and quality parameters of red wine were investigated.

Keywords: *Industry, Quality Parameters, Wine*

1. Introduction

Wine is an alcoholic fermented beverage that is made from juice of fresh grapes [1]. Among other alcoholic drinks wine has been preferred mostly and it also has a great impact on societies. Thanks to trading wine between cultures, philosophical ideas were spread and channels were opened for religious. In today it is still used in Catholic Churches as a replacement of blood of Christ [2].



Figure 2.1 Red Wine Picture[51]

1.1. History of Wine

No one knows who is the discoverer of wine, but according to an ancient Persian a women is the discoverer of wine. Fable says that she was a princess, who had lost favour with the king. She couldn't bear with the shame so she ate spoiled grapes in a jar to end her life. But it didn't go as she planned. Instead she got slumber and with a dizziness she fainted. When she awoke she felt like all of her problems have passed, so he continued to eat those spoiled grapes. By them her mood changed very much, so much so that she even regained the favour of the king. Probably discovery of wine have different stories in different regions; Ancient China, Ancient Egypt, Ancient Greece, Roman Empire; but the one known truth is that it discovered by pure luck [2][3].



Figure 2.2 Portrait of the women that discovered wine[50]

1.2. Wine Consumption in Ottoman Empire

After seeing a group of youths that were drunk in a garden quarrel, Prophet Muhammed banned wine drinking. The main reason for that, is the misuse of it. But this ban doesn't involve any rules, when it used well. So Ottoman Empire believed the logic that, a man that knows when to stop and doesn't involve any embarrassing scandals has nothing to be afraid of. This point of view was said by Ahmet Bey, an Ottoman gentleman, and surprised Lady Wortley Montague, wife of British ambassador, during a face to face meeting. Even the majority of sultans enjoyed this little gaiety with wine; for example Selim II, Sultan Beyazid I and Murad IV were the heaviest drinkers among the sultans in Ottoman Empire history. Even because of Selim II's drinking habits, Sultan Süleyman the Magnificent has banned drinking wine, in all of his reign, in İstanbul. And after three generation, this ban that lifted by Selim II reinstated by Ahmet I. So we can say that Ottoman Empire didn't have still rules and logics among its Sultans and history [4].

1.3. Wine Consumption in Turkey

Even if it is far from the wine consumption rate in Europe, Turkey is the highest wine consumption region in the Middle East. This consumption rate is 1.5 litres per person, and it corresponds 0.12 litres of pure alcohol per person. This is a small amount when we compare it with France and Portugal, which takes first and second places in 'consumption of wine in countries' ranking that has 6.74 per person and 6.25 per person respectively.

Wine is not the most preferred alcoholic drink when we compare it with rakı; and like all alcoholic drinks it has age limitation to persons 17 and under. No market can sold wine to these age group. Also to sell or serve wine, markets need to get required licences (prevention cost).

There are some more strict rules to sell wine in Turkey. For example markets can only sell alcoholic drinks between 06.00 and 22.00. It cannot be sold in less that 100 meters distance from a school or mosque. And last but not least it banned for student dormitories, health instutions and filling stations to sell wine. If someone breaks these rules, he or she has to pay big amount of fine to government (external failure cost).

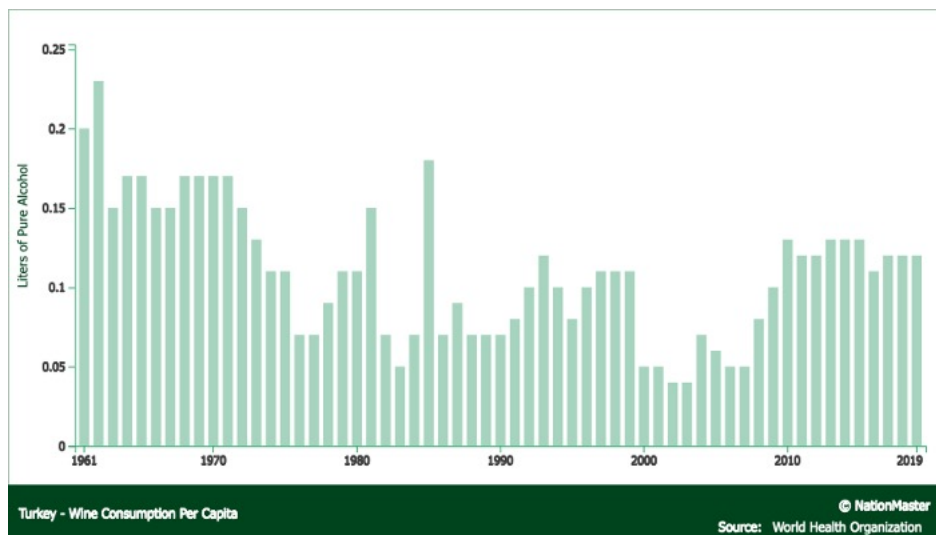


Figure2.3 Bar Plot of Wine Consumption in Turkey [6]

1.4. Alcoholic Fermentation and Its History

In history wine fermentation developed in parallel with microbiology and biochemistry. Some fermentation concepts was firstly explained by Jan Bapist van Helmont (1577-1644) with chemistry involving. Then Antoine Lavoisier (1743-1794) determined the amount of carbon dioxide and ethanol that produced during fermentation of grape juice quantitatively. By this he restored the term alcohol. In later history ‘enzymes’, which means ‘in yeast’, were introduced by Wilhelm Kühne in 1878. After Kühne Butchner carried his work forward and obtained an enzyme from a cell-free juice from yeasts that wasn’t capable of fermentation. After these studies of biochemistry and biochemical reactions help us to understand yeast and alcoholic fermentation [8].

An alcoholic fermentation has the best fermentation processes. These processes involves important transformations, stabilizations and conservation processes for sugar-rich substrates. We can give fruit and vegetable juices as an example of this substrates. This fermentation is carried out by yeasts, some fungi and bacteria [7].

The most essential alcoholic fermentation agent is *S. Cerevisiae*, and it is also used in wine fermentation as a microbiological starter. It is strongly selective on environment due to low pH, high sugar, ethanol concentrations and anaerobic conditions; so *S. Cerevisiae* becomes a dominant species for alcoholic fermentation. The reactions were start with glucose and with the biological species that makes it carry on, the reaction will continue. After some point, it will separates into two reactions. At the end of these reactions we will obtain glycerol and ethanol as a product of fermentation [7].

2. Raw Material Quality Parameters

When we analysing the quality of a wine we will see that it depends strongly on the grape quality. So if we want to produce a wine with high quality, we need to purchase grapes with high quality for the first step to obtain quality. But how can we understand that our purchased grapes have high

quality? To understand it we need to know the factors that affects grape quality; and the most efficient values, and forms of these factors. So let's start with analysing the factors that affect grape quality [9] [11].

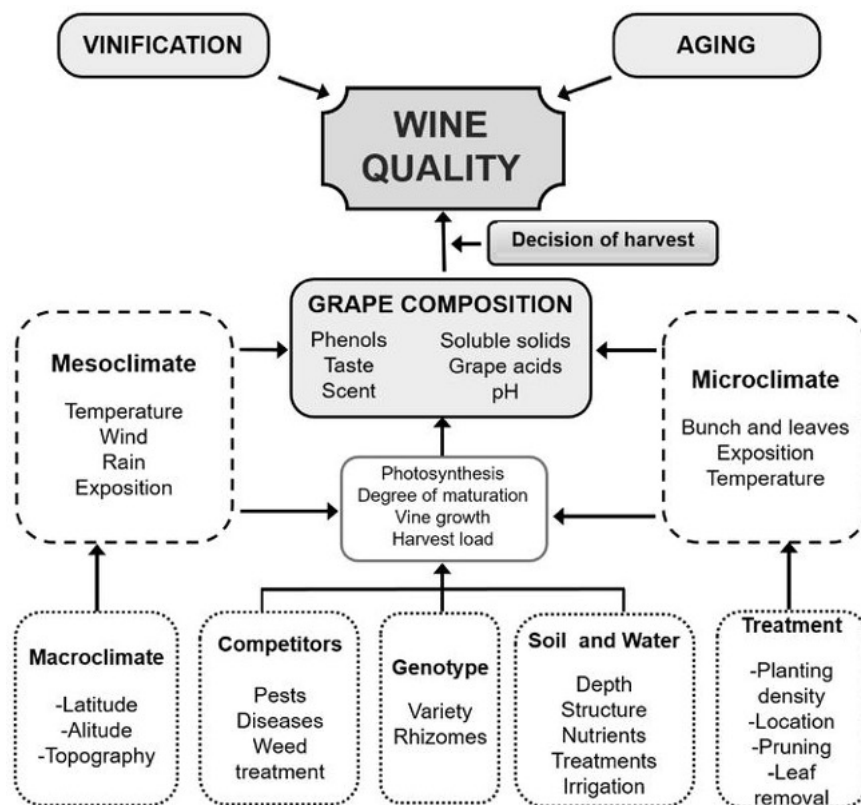


Figure 2.5 Factors that affect wine quality (grape quality) [16]

2.1. Climate

This factor determines, how much flavour and juiciness the grapes have. In climate point of view it is more easy for producers to guess how it will influence the grape quality than weather, because it is more stable than weather. Let's look at the grape feature difference between cooler climates and hotter climates [11].

- Cooler Climates: In cooler climates grapes will have difficulty in ripening. This less ripening correspond high levels of acidity, which gives them more tarty and zesty taste. If someone finds it sour and harsh, and looking for more rich wine; it will be better to buy a wine that is less acidic. Grapes will also have lower sugar values because of less ripening. This low sugar value concludes wines with lower alcohol level and lighter body. If someone prefer wine that is dry, light and crisp; it will be better to choose cooler climate wines [12] [13].

- Warmer Climates: In warmer climates, in stark construct with cooler climates, grapes will be ripen more easily. So this will lead to grapes to have lower acidity, high sugar level and darker colour. With increasing in sugar level alcohol level will be go higher, and this will make wine more full-

bodied. But it is important to not forget that high level of sugar in grapes doesn't mean that, wines that made from that grapes should taste sweet. This grapes can fermented into dry wine according to preference, and with this process you can obtain dry wine with high alcohol level. So if someone prefers wines that is more full-bodied, soft, and fruity; it will be better to choose wines that produced in warmer climates[13]

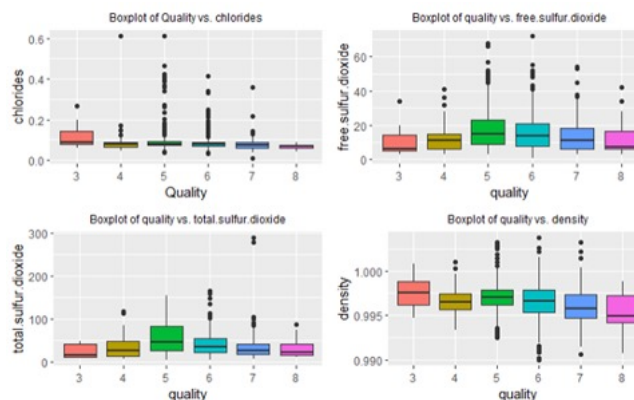


Figure 3.1 Box plot of interaction of factors that affect quality and quality by some data examples [18]

2.2. Temperature and Sunlight

- Temperature: Everyone knows from biology knowledge that photosynthesis is so important to keep a plant alive. This logic is also same for grapes. To carry out photosynthesis, grape vines should be in an environment that its temperatures will between 60 and 70 degrees Fahrenheit. That corresponds 288.7 K (15.55 Celsius) and 294.26 K (21.11 Celsius). Regions that have average temperature that close to 60 degrees F will affect successfully the short-cycle varieties. But it will be not so good for long-cycle varieties. High temperature will make grapes ripen more quickly. This will results in to need more short time amount to grape to develop its colour, flavour, and other compounds fully [11].

- Sunlight: As well as climate ripeness of grapes also connected the amount of sunlight that receive during growing. This need of sunlight is evaluated regardless of temperature. That's why reaching the required grape ripeness can be a problem in places with prolonged rain. In addition the more the rain means the lower temperatures. So this will lead to wine to be dry and highly acidic. Another possible result is watering down the grape juice. With excessive water amount in grapes, this will lead to have more diluted raw materials for wine.[13]

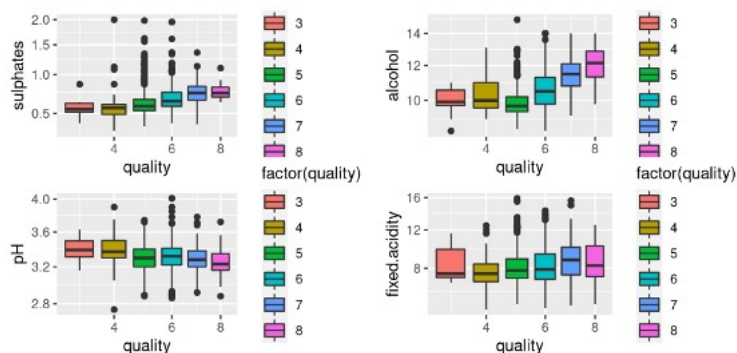


Figure 3.2 Box plot of interaction of factors that affect quality and quality by some data examples [17]

2.3. Growing Practices and Harvest

Producers' manipulations to vines will affect the wine quality as well as what land and sky provide. So farming and production techniques are important for wine quality. There are some important practices to do that [11][14].

Firstly let's know what is green pruning. In this farming technique unripe bunches of grapes were selected and cutted from the vine. By this vine can concentrate to consume its energy, nutrients and so on into the remaining bunches of grapes. This will conclude to protect the high quality of the fruit crop [14].

Like every plants grape vines also need water to survive but due to natural limitations, seasonal factors and unexpected weather phenomenon; sometimes irrigation of vineyards will be needed in order to produce grape with high quality. Without getting the water it needed, good crop hence high quality wine cannot be produced [14].

Determining the harvest time is also important for wine quality. If crop is harvested early that required time amount, grapes won't be as ripe as they should be. In that condition ripe grapes will produce highly acidic wines. On the other hand if they harvested too late, grapes will be rotten. In that condition grapes will contain high alcohol amount because of the sugar amount it contain. But it will affect wine's flavour negatively [14].

In harvest how it is done is important as well as when it is done. It can be done either by hand or mechanically. Harvest that done by mechanically will be easier but it tends to bruise the fruit, so it is non-selective. On the other hand, hand harvesting allows more sensitive and selective harvesting, that it will damage both fruits and vines less. But it is more expensive so it can only be afforded by higher-quality producers. As a result we can say that two of them both have advantages and disadvantages [14].

Lastly after harvesting hand sorting is done to remove rotten grapes that cause remaining grapes to be crushed, that are suitable to make wine. It can also done by mechanically and by hand. It will cause more money to do it by hand so again it can be practised only by high-quality wine producers. But at the end the taste of the wine will show the high-quality of the wine [14].

2.4. Preventing Fungal Diseases and Bacteria from Occurring

For wine quality it is essential to protect grapes health in the growth phase. So producers should pay extra attention in the prevention of parasite attacks on the grapevine. There are some fungal diseases that affects grapes health but the most common one is called downy and powdery mildew (*Plasmopara viticola* and *Uncinula necator*) and grey mould (*Botrytis Cinerea*). When we look at the bacterias that are dangerous for grape health, we will see grape moth (*Lobesia Botrana*), vine mealybug (*Planococcus Ficus*) and the citrus mealybug (*Planococcus Citri*) are the most dangerous ones. To fight the diseases and insects farmers usually apply pesticides. By their chemical characteristics of active ingredients, photo degradation, thermos degradation, co-distillation and enzymatic degradation; persistence of pesticides will change. This pesticides residue will turn into must onto grapes and this will influence the selection and development of yeast strains. Additionally these yeasts can influence the pesticide level in wine by reducing or adsorbing them on yeast [9].

3. Winemaking Process

Wine is a product which can be classified as both commodity and luxury. It is actually a mixture of water, sugar, ethanol and organic acids. It also includes glycerol, proteins, yeast and polyphenols. To produce a wine, the combination of traditional and modern winemaking procedures are used. It should be noted that, fine wines should be safe to drink, thus its quality is very important. The recognition of a wine is about people's opinion, so it is generally subjective. However, with contemporary techniques quality is ensured globally [19].

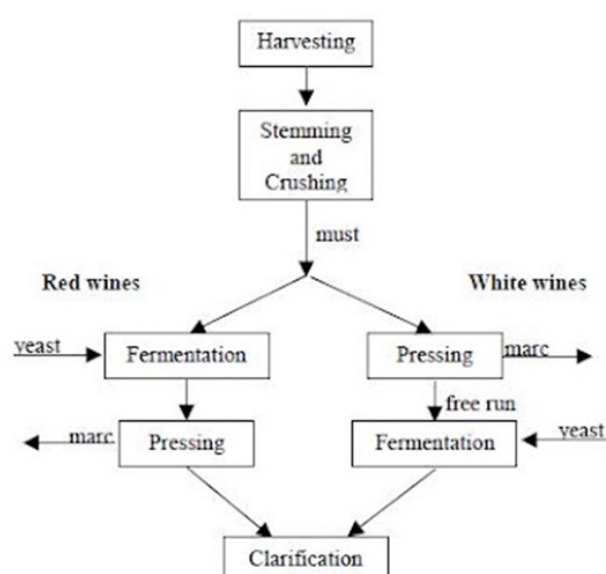


Figure 4.1 The flowchart of winemaking [47]

While winemaking, there are stages wine producers should be careful in terms of quality which are:

1. Crushing and destemming
2. Pressing
3. Maceration
4. Fermentation
5. Extraction
6. Clarification

3.1. Crushing And Destemming

The crushing and destemming one of the most important cases in winemaking. The crushing is the grape's first step to get the juice. With breaking the skins of the grape, the juice and skins touch each other. Also, in the same time juice is contacted with yeasts to maintain fermentation. There are several ways of crushing, like foot treading, hand treading, electric crushing etc. Depending on the desired wine, destemming process is changing. For red wine, stems will be taken but the skin will remain with the juice. On the other hand, for white wine both grape skins and stems will be taken. Modern crushing and destemming machines are made up of a big steel basin with a screw at the bottom. When the screw is turning the grapes, they are squeezed and separated from the stems at the same time [20] [21] [22].



Figure 4.2 The machine for crushing and destemming [48]

3.2. Pressing

In pressing process, the juice of grapes is extracted with a wine press. This process also can be held by hand. It should be noted that in white wine production, the process of pressing occurs right after the 'crushing and destemming', but in red wine production it take place after the fermentation [23].

3.3. Maceration

Maceration is one of the processes of winemaking due to which grape's phenolic substances (tannins, colouring agents (anthocyanins) and flavour compounds) are filtered from grape skins, seeds and stems into the grape juice. This is held by taking crushed grapes and soak them with its juice. This process can continue hours or weeks depending on the desired wine. Raw grape juice's actual colour is greyish so, this operation is especially for red wines since its red colour comes from this procedure. While producing white wines, maceration is generally not using. For rosé, grapes which are used in red wine production are macerated, but not as much as in red wine production. It should be noted that due to this process many flavours in the wines are brought out [24].

Grapes often need to be crushed first to initiate the maceration process. During this operation temperature is very important so that with the higher temperatures the breakdown and phenol extraction is encouraged. If it is wanted to produce red wine then, it should be known that in this maceration process also fermentation will begin. During fermentation carbon dioxide is released due to which crushed grapes will be positioned to the top of the mixture. The winemakers want to keep these crushed grapes submerged as possible. As it is stated before, the main goal in the maceration process is to extract some phenolic compounds. If the maceration period gets longer then these extracted compounds will be increased. However, the Law of Diminishing Returns eventually comes into play, as most leaching will occur early in the process and will decrease as maceration continues [24].

3.3.1. Types of Maceration

The basic maceration process includes crushing grapes, later adding sulphite and letting it to sit overnight, after that pitching the yeast. Lastly, after the fermentation is over, wine and grapes are send into a press in order to split the wine and the pulp. With changing some steps winemakers can achieve differences in their wines.



Figure 4.3 The Process of Maceration [25]

1. Cold-soak maceration: This type of maceration takes place before fermentation. Cold-soak is very common in low phenolic grapes, also it occurs with the addition of sulphur dioxide. It occurs between 5-15 °C.
2. Extended maceration: This type of maceration occurs post-fermentation. Its main goal is to optimize the phenolic extraction. It also aids final product's colour stabilization.
3. Carbonic maceration: This type of maceration is very special. It generally used for producing fruity wines with little phenolic concentrations. During this process, the grapes aren't crushed they stay in carbon dioxide tanks. Also, here fermentation is occurred by enzymes rather than yeast. Due to this operation light bodied wines are obtained since, grape skins' and juice's contact time is little [25].

3.4. Fermentation

In winemaking one of the most important steps is fermentation. It should be noted that like in the maceration process, here in fermentation also there are differences between the red-white-rosé wines. For the fermentation process, yeasts are added to the grape juice. With these yeasts natural sugars (glucose & fructose) inside the grapes are converted into ethanol and carbon dioxide. It worth bearing in mind that fermentation process isn't just about creating alcohol. Due to this process the taste, aroma and appearance of the wine is constructed.

The utilization of yeast in fermentation is very crucial and there are thousands of types of yeasts, knowing where to use which yeasts are very important. This is one of the most important quality parameters. For instance, usage of wild yeast is risky since it is unpredictable. On the other hand, when it is used, it creates unique flavours. Thus, to get this unique flavours winemakers tends to use cultured yeasts. Nowadays, there are plenty of cultured yeast types. To keep them active, winemakers should provide enough minerals, vitamins and other components to these yeasts [26].

3.4.1. Perfect Condition for Fermentation

In the previous part it's been mentioned that usage of yeast in fermentation is very important. However, this is not enough. Winemakers should also create suitable conditions for wines. These conditions can be listed as:

1. Sugar content
2. Temperature
3. Fermentation place

First of all, sugar is vital for the fermentation process. If great amount of sugar is added, then yeast will produce more alcohol. However, if there is excess amount, then yeast will be stressed and undesired flavours might be obtained. Also, fermentation temperature is essential. For example, red wine's ideal fermentation occurs in high temperatures, but white wine's ideal fermentation occurs in colder temperatures. To obtain different tastes some winemakers choose to change these ideal temperatures. The right fermentation place is also another factor. For instance, for fermenting the white and rosé wines, large stainless steel tanks are used and for red wines generally oak barrels are used [26].

3.4.2. Types of Wine Fermentation

Most wines on the market undergoes more than single fermentation. In the first fermentation process alcohol and flavour boosting compounds are obtained. The other fermentations can be indicated as:

1. Malolactic fermentation
2. Bottle fermentation

For the malolactic fermentation utilization of bacteria is very crucial. Due to bacteria, malic acid is converted into lactic acid and taste of a wine becomes softer and less tart. The bottle fermentation is especially for sparkling wines like champagne. Here fermentation occurs after bottling. Due to this process champagne's bubbles are formed [26].

3.5. Extraction

Extraction process in winemaking refers to obtaining flavour, colour, and tannin from grapes. This process is mainly for red wines since one of the main problems in red wine making is acquiring flavour and colour from grapes' skins. Because, the pulp of nearly every grape is colourless, but their skins are highly pigmented. The method used in extraction is vital in the sense of quality. "Extraction is about building the core structure of the wine," says James Hall, founder and winemaker at Patz & Hall in Sonoma.

Winemakers use cold maceration and extended maceration as extraction methods. It should be noted that like in everything, here also balance is important. Unfortunately, over-extraction is an increasing fault nowadays. To determine the appropriate period of extraction, the type of the grape is also important rather than the quality and wine making style. For instance, if it is wanted to compare Cabernet Sauvignon and Pinot Noir, it will be observed that even both make red wines, Cabernet Sauvignon can withstand to the intense extraction more than Pinot Noir. If Pinot Noir is extracted a lot then it will become blurry and undesirable [27] [28] [29].

3.6. Clarification Of Wine

Clarification in winemaking refers to removing the insoluble matters from wine before bottling. These insoluble matters might be dead yeast cells, tartrates, pectin, tannins, phenolic compounds and bacteria. Also, if there remained any grape skin, pulp and stems are also removed with this step. If there is no visible particles in a wine, then this wine is considered to be 'clear'. In this process, there is a step which is named as fining. In fining, fining agent is added to the wine due to this addition larger particles and molecules precipitate rapidly. There is also another step which is named as filtration. In this step wine passes through filters and particles which are bigger than filters' holes are captured [30].

4. Analyses For Quality Of Wine

In the production of wine, quality control has a pivotal role. Food analysis and safety laboratories help wine industry. There are some procedures due to which quality of wine is determined. These following analyses should be done both at the harvest and in final. Which are:

4.1. Analytical Testing In Production Process

During wine production, analytical tests are implementing, since it is crucial especially for successful fermentation. Here, both classical chemical analysis and modern analytical techniques are being utilized. It ensures taking precautions or making adjustments.

4.2. pH Levels

With using pH meter pH of the wine can be indicated. In general the pH of wine is between 2.9 and 3.9. The values change because in every wine the amounts of proteins, sulphides, tannins and polyphenols might differ.

4.3. Acid Levels

With the classical titration, acid level of a wine can be measured easily. Alternatively, Gallery discrete photometric analyser is used when great amount of wine samples are need to be tested.

4.4. Sugar Levels

The levels of sugar are indicated with refractive index (RI). To determine the optimum harvesting time, the grapes are tested regularly for their sugar content. Also, to understand the fermentation's finishing time sugar levels are controlled again.

4.5. Nitrogen Levels

To have a high quality of wine nitrogen analysis should be implemented, since nitrogen is yeast's one of the essential nutrients. Amount of nitrogen affects the fermentation process. It also affects the process of clarification and final composition of wine [31].

4.6. Glycerol Levels

With the help of enzymatic assay, glycerol levels can be tested. Glycerol maintains the sweetness and mouthfeel of wine, thus to analyse its amount is very important.

Other than these previous analyses, also acetaldehyde, sulphite, organic acids and pesticides should be tested. Since they maintain colour, preservation, taste etc. [32].



Figure 5.1 Picture from wine testing [49]

5. Bottling Process

Hygiene is a must at all stages of the wine production process. It is a condition specified by the manufacturer. The hygiene of bottles requires special attention. The method must begin with the sterilization of the bottles before proceeding with the bottling.[33]

Cleaning bottles can be done with either specific products or a solution of water and potassium metabisulfite. It's enough to dissolve 3-4 teaspoons of potassium metabisulfite for every liter of water to clean the bottles. All of the bottles and bottling tools will be thoroughly washed with this solution. [33]

Bottling wine is a critical and delicate process, despite its seeming simplicity, because it is theoretically impossible to work on the wine's quality and stability after the bottle has been sealed with a cork. [33]

In fact, if a problem or fault occurs during the aging of wine in a cask, or in any other container, it will be possible to fix it by taking appropriate measures and corrections. This is something that is clearly not possible once the wine has been bottled. [33]

Production teams must arrange a plan to ensure that the wine is bottled in the finest possible condition. As a result, it is critical to verify the wine's stability and health prior to bottling. It will also be necessary to guarantee the ideal conditions for both bottles and corks. Also, necessary measures and circumstances must be considered when storing bottles, especially if natural corks are used. They may lose their elasticity, or they may cause undesirable odors or flaws in the wine. [33]

5.1. Choosing Bottles and Corks

Although this may appear to be excessive, the choice of bottles and corks is an important aspect in the bottling process. Corks' quality and health allow a better long-term storage and a lower chance of wine spoiling. The distinctive "corky smell," created by a chemical molecule known as 2,4,6-trichloroanisole, or 246-TCA in short, is one of the most common dangers. Corks should be selected based on the type of wine that will be produced. Choosing a high-quality natural cork for red wines that will be aged in bottles for a long time is essential. [33]

Most commonly selection of a high-quality natural cork with a minimum length of 45 millimeters is preferable. Synthetic corks, never generate corky smell defect, are an excellent choice for white wines, or wines consumed within a few months of harvesting.

Another option is agglomerated corks, which may be used for both young and old red wines and have the advantage of being less expensive. In any instance, corks with a minimum length of 45 millimeters are recommended, regardless of the type of cork used.

The bottle selection must also be done with care. Apart from issues of tradition, in all cases when a territory distinguishes its wines also by the shape of the bottle, it is important to note that each bottle has its own qualities. [33]

When it comes to red wines that will be aged for a long time and will create a significant amount of sediments, a bottle with a fairly steep shoulder, such as the Bordelaise bottle, is required. The shoulder of this bottle acts as a handy barrier during the pouring process, trapping any possible sediment. White wines can be served in Bordelaise bottles, but Burgundy or flute bottles are preferred. The tint of the glass is critical because it provides crucial shielding from the impacts of light. As a result, dark green or brown-colored glass bottles are the ideal choice. [33]

6. Labelling Process

In the world of wine, labels are quite essential. They serve a number of purposes, including catching attention and distinguishing a wine from its competitors, as well as providing important product information and being a legal necessity. It's not always easy to comprehend wine labels. Whereas some of the countries have very basic wine labeling methods, others might have highly complicated wine labeling traditions. [34]

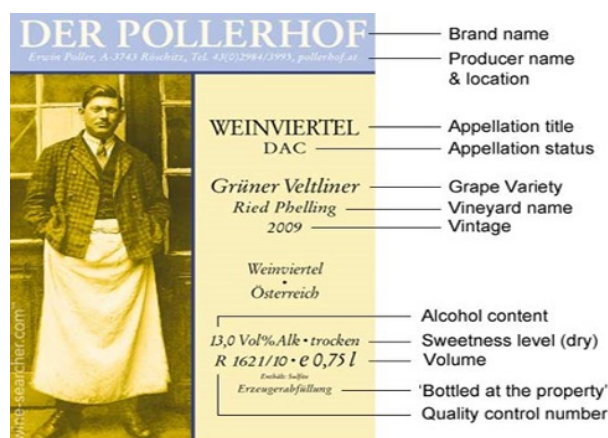


Figure 7.1 An Example of Traditional Wine Labelling in Austria [34]

6.1. Wine Labelling Procedures

Each country has its own set of rules about what must be printed on wine labels. The most visible information on a normal wine label is the name of the producer or brand, the location of origin, the vintage and in some cases, the grape variety or blend used to make the wine. Aside from that, practically every country requires,

- the producer's location,
- the bottle's volume,
- the wine's alcohol concentration,
- whether or not it contains allergens
- government warnings (about the age of the consumer, risk of birth defects, ability to drive a car etc.) to be listed on the label. [34][35]

If any of the 14 allergens identified by food legislation are present in the product, a declaration on one of the labels is required:

Wines with,

- Sulphur dioxide, sulphites, sulfites (if the SO₂ content exceeds 10 mg/litre)
- egg, egg protein, egg product, egg lysozyme or egg albumin
- milk, milk products, milk casein, or milk protein must all have the term 'contains' in the wording. [34][35]

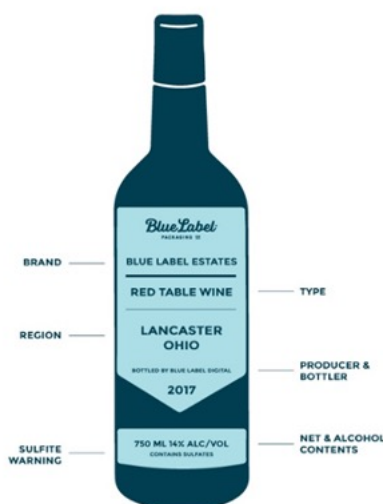


Figure 7.2 Representation of very classical Wine Labelling

6.2. Quality and Classifications

Price and quality are the two most significant factors to consider when purchasing wine. While statistics may easily and correctly express costs, consistently indicating quality is significantly more difficult. Brand quality can shift greatly over time, and brand-positive impression can be established by spending in marketing rather than winemaking. Therefore winemakers are working so hard to come up with strategies to objectively discern high-quality wines from low-quality wines. [34]

7. Wine Aging Process

Wine aging can increase the quality of the wine. This sets wine apart from most other consumables. While wine is perishable and susceptible to deterioration, complicated chemical interactions involving the wine's sugars, acids, and phenolic compounds can modify the aroma, color, mouthfeel, and taste. Many factors have an impact on the capacity of a wine to age.[44]

For instance; variety, vintage, viticultural methods, wine region, and winemaking style. After bottling, the condition of the wine has an impact on how well it matures and may necessitate a large time and cost investment.[44]

The quality of an aged wine varies from bottle to bottle. That is because of the storage circumstances as well as the state of the bottle and cork, and hence it is claimed that there are good old bottles rather than good old vintages. The great majority of wine is not matured, 90 percent of wine is intended to be consumed within a year of manufacture, and 99 percent within five years. [44]

7.1. Ideal Conditions for Wine Aging

Long-term wine storage requires a temperature of 55° Fahrenheit and a relative humidity of 60-65 percent. Low temperatures slows the aging process, while the high humidity prevents moisture from flowing into the cork and evaporating into the air inside the wine bottle. Exposure to ultraviolet radiation should be maintained to a minimum level.[45]

In wine aging process, in order to make sure that wines ages properly, every detail counts. Bottles require a quiet, cold, humid environment with enough ventilation. In a wine cellar, these are the best wine storage conditions to keep in mind:[45]

- a temperature of around 12°C,
- a relative humidity approximately %65
- high air quality,
- low light levels,
- perfect stability (orientation)

7.1.1. Temperature Conditions

A wine cellar's optimal wine storage temperature is 12°C, which provides ideal conditions for storing and aging wines. White wines like temperatures between 10 and 12 degrees Celsius, while red wines prefer temperatures between 12 and 14 degrees Celsius. As a result, a temperature of 12°C is the ideal compromise between the two requirements.

Wine will mature too rapidly and lose many of its aromas and characteristics if the cellar is too warm. The cellar, on the other hand, will not offer the necessary conditions for the wine to mature correctly if the climate is too chilly.[44][45]

7.1.2. Humidity Conditions

In a wine cellar, maintaining a steady humidity level in the air of approximately 65% is critical. Excessive humidity can raise the danger of fungal growth on the corks in wine bottles. On the other hand, if the atmosphere is excessively dry, the cork's watertight seal may be jeopardized, hastening the wine's aging process. By using hygrometer, humidity level can be monitored.[44][45]

7.1.3. Light Conditions

Tannins (which exist in wine composition chemically) are light-sensitive, especially to daylight. Lower light level in a wine cellar is better. Most of the time bottles should be kept in the dark. [44][45]

7.1.4. Air Conditions

A wine cellar should be softly aired, which will assist keep the humidity and temperature in the cellar consistent. Always ventilation is required. [44][45]

In a wine cellar, air quality is also critical. Wine breathes through the cork stopper's pores and is sensitive to strong odors. As a result, it's critical to avoid bad air quality, which may impact negatively the flavor of wine and damage the result of years of patience. [44][45]

7.1.5. Stillness Conditions

To maintain the preservation and natural development of its flavors, a bottle of wine should be kept still. One of the most important aspects of a good wine cellar is its capacity to endure shaking or vibrations. Because even the tiniest movement can cause wine to get stressed, a wine cellar is built to keep each bottle absolutely steady and motionless for longer durations. [44][45]



Figure 8.1 Representation of wines aging in the cellar [43]

8. Storage Process

Wine storage is a significant issue for wine that will be aged for a long time. Fine wines are frequently kept in the cellar for long periods of time. Wine is one of the product that improves in flavor and value with age but unfortunately it can also quickly deteriorate if stored improperly.[36]

8.1. Storage Conditions

Light, humidity, temperature and orientation are the four elements that have the greatest direct impact on the condition of a wine.

8.1.1. Light Effect

Direct effect of sunlight can cause phenolic chemicals in wine to react, resulting in "wine defects." When wine is exposed to light from any source, the flavor and aroma of the wine can vary.[36]

Light-bodied white wines are the most vulnerable to light exposure, hence they are frequently packaged in tinted wine bottles that provide some protection. Wines packaged in clear, pale green or blue bottles may require additional storage precautions. Wines are stored in corrugated boxes or wooden crates in the cellar or storehouses to keep them out of direct sunlight. [36]

8.1.2. Humidity Effect

To protect wines with cork enclosures from drying out, a certain amount of humidity is essential. One side of the cork is exposed to air even when wine bottles are placed on their sides. If the cork begins to dry up, oxygen can enter the bottle, filling the ullage gap and potentially spoiling or oxidizing the wine. Excessive humidity can also damage wine labels, making them difficult to identify and lowering their resale value. One of the main reasons why wine experts advise against

storing wine in the refrigerator is that the refrigeration process frequently includes dehumidification.[36]

8.1.3. Temperature

The ideal temperature is determined by a number of elements including the amount of fruit, alcohol, tannin in the wine. Wine should be stored at 11-14 degrees Celsius (52-57 degrees Fahrenheit) as a general rule. Wine storage temperatures should never exceed 24 degrees Celsius, as this causes oxidation, which is bad circumstance for the wine.

Temperature changes in wine storage should be avoided at all, since they can cause serious damage to the wine. To develop properly, a bottle of wine requires a steady temperature throughout the year. [36]

8.1.4. Orientation of the Bottle

Horizontal wine storage is a great way to keep the wines organized in racks. This keeps the cork moist and swollen, preventing wine from coming into touch with air or air pockets. When wine bottles are placed horizontally this creates a advantage to sediment falling to the side of the bottle, consequently preventing spoiling when the wine is poured. This option is ideal for long-term storage.[37]

9. Transportation Process

Logistics is a major concern in the wine industry. Wine logistics is a cost-concerned topic as well as a business challenge that necessitates well-planned organization, the use of technology and complicated IT systems at all levels.[41]

Wine does not consume just in the regions where it produced, hence transportation is necessary. Nowadays, wine is usually bottled somewhere other than where it is consumed by customers. Consequently, it must be transported to several regions of the world.[41]



Figure 10.1 Wine Shipping in Overseas

9.1. Factors That Affecting Wine Quality during Transportation Process

9.1.1. Temperature

Temperature variations are the most harmful element for wine quality during transit, according to several studies, because they can create irreversible changes in the chemical and sensory profiles of the product, as well as accelerate the ageing process. In fact, storing wine at temperatures above 25°C for an extended period of time will degrade its quality permanently. If a temperature of over 40°C is reached for even a short period of time, visual and sensory variations will occur.[43]

9.1.2. Vibrations

Vibrations, even if just for a short time (15 days), might affect the wine's overall quality. They have an adverse influence on the organoleptic characteristics of a wine. Vibrations at a high rate would:

- Increase overall acidity in red wines
- increase the decomposition of organic acids and tannins
- reduce propanol and isoamyl alcohol content[42]

9.1.3. Transportation Containers

When shipping loose wine (non-bottled), producer will have a lot of alternatives for transportation. Liquid transportation may be done in a variety of containers while keeping the taste, scent, and safety of the liquid.[38][39][40]

- Flexitanks

Flexitanks resemble a large, inflatable waterbed that can fit inside a regular shipping container.[40]

Flexitanks have the advantage of being simple to carry huge amounts of liquid. A normal flexitank may hold up to 24,000 liters of liquid. Because the glass bottle accounts for 40% of the net weight of a full bottle of wine, it is also considerably lighter than shipping bottled wine.[40]

- ISO Tanks

A cylindrical ISO tank fits inside a 20-ft container frame. ISO tanks have a number of advantages including the fact that they are massive steel containers that provide the most security. They also have airtight closures, which help preserve wine's delicate flavors and aromas. Finally, their substance is simple to clean, reducing the risk of cross-contamination with other wines or liquids. [40]



Figure 10.2 Wine Transportation by Using Tanks [43]

9.1.4. Packaging

When transporting the wine bottles, extra precautions must be considered. High or low temperatures, vibration, humidity or light are all easy ways to disrupt wine's delicate chemistry. Fine red wines are particularly vulnerable to harm during transport. The danger of degradation of wines can be easily minimized by carefully planning and packing the products.

For instance, red and white wines should be stored on their sides or upside down. This keeps corks moist and prevents oxidation and spoiling.[43]

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