CHAPTER 1

INTRODUCTION

1.1 Statement of the problems

Wine is a worldwide popular fermented alcoholic beverage. Wine can be prepared from varieties of fermented fruits, especially grapes. Specially, red wine is known as the most favorite softening wine for many epicures and other consumers all over the world. Wine production starts when grapes are fermented in appropriate time. A key of softening wine is yeast. During wine fermentation, while grape sugar is being changed into ethanol by filled yeast, color and any coloring substances in grapes are distilled into specific aroma and flavor of each wine. These special chemical reactions depend on the types of chosen yeast and species of grapes as well. After fermentation, wine is moved to second important "aging" process in oak barrel where ethanol and other acids in the wine are reacted and distilled by oak chip slowly. Finally, the aging with oak creates softening aroma and flavor in wine (Carrillo, Garrido-Lopez and Teresa, 2006).

Aging wine is traditionally done in the barrels made from oak wood. Aging chemicals in oak wood are extracted out and mixes with wine juice. Chemical changes occur in wine juice itself will make the wine to have smoother taste of more complex flavor. The flavor of oak includes oak lactones which is a specific flavor of brandy and whiskey through appropriate aging. In addition, there is an esterification between organic acids and alcoholics lowering acidity combined with the present of ester which is a unique flavor that also affects wine (Garde and Ancin, 2006). The advantages of esters reaction are to reduce wine acidity during aging time. Ester is a unique flavor that causes the special taste of wine. Wine aging in one period will balance acid, alcohol and ester. Other compounds of oak will also affect wine while aging. Phenolic compounds in the wood will react with water and give a flavor similar to vanilla or flavored tea, depending on the way of roasting. Roasted oak wood before aging will impact on the level of tannin in the wine and hydrolyzable tannin (e.g. ellagitannins) from lignin in wood. It was found that if the roasted wood is used, we can get mocha and toffee flavor in red wine (Ribereau, *et.al.*, 2000 and Sanchez-Moreno, Larrauri and Saura-Calixto, 1999).

Oak barrels is available from the starting of fermentation process but sometime used only in the process of wine aging. In the aging stage, it was found that wine aging in oak barrels will give a better flavor and taste than fermentation in oak barrels. Other wood types, including chestnut, pine, redwood, and acacia, have been used in large fermentation or aging in wine making. However, none of these wood types, unlike oak wine, has demonstrated in combining it's water tight, yet slightly porous, storage capabilities with the unique flavor and texture characteristic where it can impart to the wine that it is in contact with (Teresa, *et.al*., 2007 and Wang, Cao and Prior,1996).

Nowadays, most of Thai consumers awakened towards wine and alcohol drinking as a high taste. They desire quality, aroma, flavor, satisfaction, and health benefits from wine. For instance, it is believed that drinking a glass of wine per day will nourish health by its antioxidation. Therefore, wine becomes valuable and needed products in Thai drinking business.

Nevertheless, though Thai government tries to support winegrowers and trade with "One Tambon, One product" campaign (OTOP), wine is still precious expensive drinking and cannot be afforded, especially great wine. Since imported oak barrels are necessary towards the taste of wine in aging process and Thai winegrowers cannot afford expensive oak, they face a problem with unaccepted wine flavor in public.

This research aims to offer other choices of wood that found in local Northern area in Thailand for wine aging. The research focuses on several important essentials and antioxidation activity from chosen wood chips such as luna nut(*Lepisanthes fruticosa* Leenh.), longan(*Dimocarpus longan* Lour.), black poum(*Cleistocalyx nervosum* var. paniala), neem(*Azadirachta indica*), drumstick(*Moringa oleifera* Lam.) and oak(*Quercus* sp.). Oak wood was use as standard control. Several types of wood chips were fermented with prepared wine in aging process. Each wine from fermented wood chips was analyzed subsequently for its organoleptic qualities and quantities of substances which are responsible for its antioxidation activity were also evaluated.

1.2 Wine

1.2.1. Wine making (Jancis, 2006)

Winemaking, or vinification, is the production of wine, starting with selection of the grapes or other fruits ending with bottling the finished wine. Although most wine is made from grapes, it may also be made from other fruits or non-toxic plant materials. Mead is a wine that made with honey as the primary ingredient along with water. Winemaking can be divided into two general categories: still wine production (without carbonation) and sparkling wine production (with carbonation). The science of wine and winemaking is known as oenology (in American English, enology).

1.2.2 Wine making process

After harvesting, grapes are crushed and allowed to ferment. Red wine is made from the must (pulp) of red or black grapes that undergoes fermentation together with the grape skins. On the other hand, white wine is usually made by fermenting juice pressed from white grapes, but can also be made from the must extracted of from red grapes with minimal contact with the grapes' skins. Another type, rose wine is made from red grapes where the juice is allowed to stay in contact with the dark skins long enough to pick up a pinkish color, but little of tannins contained in the skins.

During this primary fermentation, which often takes between one and two weeks, yeast converts most of the sugars in the grape juice into ethanol and carbon dioxide. After the primary fermentation, the liquid is transferred to vessels for the secondary fermentation. Here, the remaining sugars are slowly converted into alcohol and the wine becomes clear. Some wines are then allowed to age in oak barrels before bottling, which add extra aromas to the wine, while others are bottled directly. Still others may be aged in stainless steel tanks or glass carboys. The time from harvest to drinking can vary from a few months for Beaujolais new wines to over twenty years for top wines. However, only about 10% of all red and 5% of white wine will taste better after five years than it will after just one year (Jancis, 2006). Depending on the quality of grape and the target wine style, some of these steps may be combined or omitted to achieve the particular goals of the winemaker. Many wines of comparable quality are produced using similar but distinctly different approaches to their production; quality is dictated by the attributes of the starting material and not necessarily the steps taken during vinification (How to make homemade wine, 2002).

Variations on the above procedure exist. With sparkling wines such as Champagne, an additional fermentation takes place inside the bottle, trapping carbon dioxide and creating the characteristic bubbles. Sweet wines are made by ensuring that some residual sugar remains after fermentation is completed. This can be done by harvesting late (late harvest wine), freezing the grapes to concentrate the sugar (ice wine), or adding a substance to kill the remaining yeast before fermentation is completed; for example, high proof brandy is added when making port wine. In other cases, the winemaker may choose to hold back some of the sweet grape juice and add it to the wine after the fermentation is done, a technique known as “sweet reserve”.

Moreover, the process produces wastewater, pomace, and lees that require collection, treatment, and disposal or beneficial use.

1.2.3 Grapes

The quality of the grapes determines the quality of the wine more than any other factor. Grape quality is affected by variety as well as weather during the growing season, soil minerals and acidity, time of harvest, and pruning method. The combination of these effects is often referred to as the grape's terroir.

Grapes are usually harvested from the vineyard in the autumn (fall), in the northern hemisphere from early September until the beginning of November, or the middle of February until the beginning of March in the southern hemisphere (Blog Cellarer, no date). In some cool areas in the southern hemisphere, for example Tasmania, Australia, harvest extends into the month of May.

The most common species of wine grape is *Vitis vinifera*, which includes nearly all varieties of European origin.

1.2.4 Harvesting and de-stemming

The grape harvest is the picking of the grapes and in many ways the first step in wine production. Grapes are either harvested mechanically or by hand. The decision to harvest grapes is typically made by the winemaker and informed by the level of sugar in °Brix, acid identify acidity as expressed by tartaric acid equivalents and pH of the grapes. Other considerations include phenological ripeness, berry flavor, tannin development responsible for seed colour and taste. Furthermore, overall disposition of the grapevine and weather forecasts are also taken into account.

Mechanical harvesters are large tractors that straddle grapevine trellises, using firm plastic or rubber rods or, strike the fruiting zone of the grapevine to dislodge the grapes from the rachis. Mechanical harvesters have the advantage of being able to cover a large area of vineyard land in a relatively short period of time, and with a minimum investment of manpower per harvested ton. A disadvantage of mechanical harvesting is the indiscriminate inclusion of foreign non-grape materials in the product, especially leaf stems and leaves. The foreign materials depends on the trellis system and grapevine canopy management that may include moldy grapes, canes, metal debris, rocks and even small animals and bird nests. Some winemakers remove leaves and loose debris from the grapevine before mechanical harvesting to avoid such material being included in the harvested fruit. In the United States, mechanical harvesting is seldom used for premium winemaking because of the indiscriminate picking and increased oxidation of the grape juice. In other countries (such as Australia and New Zealand), mechanical harvesting of premium wine-grapes is more common because of general labor shortages.

Manual harvesting is the hand-picking of grape using knowledgeable labor. Manual harvesting has the advantage of to not only pick the ripe clusters but also to leave behind the clusters that are not ripe or contain bunch rot or other defects that can effectivefirst line of defense to prevent inferior quality fruit from contaminating a lot or tank of wine.

Destemming is the process of separating stems from the grapes. Depending on the winemaking procedure, this process may be undertaken before crushing with the purpose of lowering the development of tannins and vegetal flavors in the resulting wine. Single berry harvesting, like what is done with some German Trockenbeerenauslese, avoids this step all together with the grapes being individually selected.

1.2.5 Crushing and primary fermentation

Crushing is the process of gently squeezing the berries and breaking the skins to start to liberate the contents of the berries. In traditional and smaller-scale wine making, the harvested grapes are sometimes crushed by trampling them barefoot or by the use of inexpensive small scale crushers. However, in larger wineries, a mechanical crusher/destemmer is used. The decision about desteming is different for red and white wine making. Generally when making white wine the fruit is only crushed, the stems placed in the press with the berries. The presence of stems in the mix facilitates pressing by allowing juice to flow pass flattened skins. These accumulate at the edge of the press. For red winemaking, stems of the grapes are usually removed before fermentation since the stems have a relatively high tannin content; in addition to tannin they can also give the wine a vegetal aroma due to extraction of 2-methoxy-3-isopropylpyrazine which has an aroma reminiscent of green bell peppers. On occasion, the winemaker may decide to leave them in if the grapes themselves contain less tannin than desired. This is more acceptable if the stems have 'ripened' and started to turn brown. If increased skin extraction is desired, a winemaker might choose to crush the grapes after destemming. Removal of stems first means no stem tannin can be extracted. In these cases the grapes pass between two rollers which squeeze the grapes enough to separate the skin and pulp, but not so much as to cause excessive shearing or tearing of the skin tissues. In some cases, notably with "delicate" red varietals such as Pinot noir or Syrah, all or part of the grapes might be left uncrushed (called "whole berry") to encourage the retention of fruity aromas through partial carbonic maceration.

Most red wines derive their color from grape skins (the exception being varieties or hybrids of non-vinifera vines which contain juice pigmented with the dark Malvidin 3,5-diglucoside anthocyanin) and therefore contact between the juice and skins is essential for color extraction. Red wines are produced by destemming and crushing the grapes into a tank and leaving the skins in contact with the juice throughout the fermentation (maceration). It is possible to produce white (colorless) wines from red grapes by the fastidious pressing of uncrushed fruit. This minimizes contact between grape juice and skins (as in the making of Blanc de noirs sparkling wine, which is derived from Pinot noir, a red vinifera grape.)

Most white wines are processed without destemming or crushing and are transferred from picking bins directly to the press. This is to avoid any extraction of tannin from either the skins or grapeseeds, as well as maintaining proper juice flow through a matrix of grape clusters rather than loose berries. In some circumstances winemakers choose to crush white grapes for a short period of skin contact, usually for 3 to 24 hours. This serves to extract flavor and tannin from the skins (the tannin being extracted to encourage protein precipitation without excessive bentonite addition) as well as potassium ions, which participate in bitartrate precipitation (cream of tartar). It also results in an increase in the pH of the juice which may be desirable for overly acidic grapes. This was a practice more common in the 1970s than today, though still practiced by some Sauvignon blanc and Chardonnay producers in California.

In the case of rose wines, the fruit is crushed and the dark skins are left in contact with the juice just long enough to extract the color that the winemaker desires. The grape must is then pressed, and fermentation continues as if the winemaker was making a white wine.

Yeast is normally already present on the grapes, often visible as a powdery appearance of the grapes. The fermentation can be done with this natural yeast, but since this can give unpredictable results depending on the exact types of yeast that are present, cultured yeast is often added to the must. One of the main problems with the use of wild ferments is the failure for the fermentation to go to completion, that is some sugar remains unfermented. This can make the wine sweet when a dry wine is desired. Frequently wild ferments lead to the production of unpleasant acetic acid production as a by product.

During the primary fermentation, the yeast cells feed on the sugars in the must and multiply, producing carbon dioxide gas and alcohol. The temperature during the fermentation affects both the taste of the end product, as well as the speed of the fermentation. For red wines, the temperature is typically 22 to 25 °C, and for white wines 15 to 18 °C (How to make homemade wine, 2002). For every gram of sugar that is converted, about half a gram of alcohol is produced, so to achieve a 12% alcohol concentration, the must should contain about 24% sugars. The sugar percentage of the must is calculated from the measured density, the must weight, with the help of a saccharometer. If the sugar content of the grapes is too low to obtain the desired alcohol percentage, sugar can be added calling chaptalization. In commercial winemaking, chaptalization is subject to local regulations.

During or after the alcoholic fermentation, malolactic fermentation can also take place, during which specific strains of bacteria convert malic acid into the milder lactic acid. This fermentation is often initiated by inoculation with desired bacteria.

1.2.6 Pressing

Pressing is the act of applying pressure to grapes or pomace in order to separate juice or wine from grapes and grape skins. Which is not always a necessary act in winemaking. If grapes are crushed there is a considerable amount of juice immediately liberated (called free-run juice) that can be used for vinification. Typically this free-run juice is of a higher quality than the press juice. However, most wineries do use pressing in order to increase their production (gallons) per ton, as pressed juice can represent between 15%-30% of the total juice volume from the grape.

Pressing is done by positioning the grape skins or whole grape clusters between a rigid surface and a moveable surface and slowly decrease the volume between the two surfaces. Modern techniques are able to follow a pressing program which dictates the duration and pressure at each press cycle, usually ramping from 0 Bar to 2.0 Bar. Sometimes winemakers choose pressures at which they wish to separate the streams of pressed juice, which is called making "press cuts." As the pressure increases on the grape skins so too increase the amount of tannin extracted into the juice, often rendering the pressed juice excessively tannic or harsh. Because of the location of grape juice constituents in the berry (water and acid are found primarily in the mesocarp or pulp, whereas tannins are found primarily in the pericarp, or skin, and seeds), pressed juice or wine tends to be lower in acidity with a higher pH than the free-run juice.

Before the advent of modern winemaking, most presses were basket presses made of wood and operated manually. Basket presses are composed of a cylinder of wooden slats on top of a fixed plate, with a moveable plate that can be forced downward (usually by a central ratcheting threaded screw.) The press operator would load the grapes or pomace into the wooden cylinder, place the top plate in place and begin to lower it until juice began to flow from the wooden slats. As the juice flow decreased to a minimum, the plate was ratcheted down again until a similar flow rate was achieved. This process would continue until the press operator determines that the quality of the pressed juice or wine is below standard, or all liquids have been pressed from the grape skins. Since the early 1990s, modern mechanical basket presses have seen a resurgence amongst higher-end producers seeking to replicate the gentle pressing of the historical basket presses. Because basket presses have relatively compact design, the press cake offers a longer relative pathway through which the juice must travel before leaving the press. It is believed by advocates of basket presses that this relatively long pathway through the grape or pomace cake serves as a filter to solids that would otherwise negatively impact the quality of the press juice.

With red wines, the must is pressed after the primary fermentation, which separates the skins and other solid matter from the liquid. With white wine, the liquid is separated from the must before fermentation . With rose, the skins may be kept in contact for a shorter period to give color to the wine, in that case the must may be pressed as well. After a period in which the wine stands or ages, the wine is separated from the dead yeast and any solids that remained (called its lees), and transferred to a new container where any additional fermentation may take place.

1.2.7 Pigeage

Pigeage is a French winemaking term for the traditional stomping of grapes in open fermentation tanks. To make certain types of wine, grapes are put through a crusher and then poured into open fermentation tanks. Once fermentation begins, the grape skins are pushed to the surface by carbon dioxide gases released in the fermentation process. This layer of skins and other solids is known as the cap. As the skins are the source of the tannins, the cap needs to be mixed through the liquid each day, or "punched," which traditionally is done by stomping through the vat.

1.2.8 Cold and heat stabilization

Cold stabilization is a process used in winemaking to reduce tartrate crystals (generally potassium bitartrate) in wine. These tartrate crystals look like grains of clear sand, and are also known as "wine crystals" or "wine diamonds". They may appear to be sediment in the wine, but they are not. During the cold stabilizing process, the temperature of the wine, after fermentation, is dropped to close to freezing for 1-2 weeks. This will cause the crystals to separate from the wine and stick to the sides of the holding vessel. When the wine is drained from the vessels, the tartrates are left behind.

During "heat stabilization", unstable proteins are removed by adsorption onto bentonite, preventing them from precipitating in the bottled wine (Blog Cellarer, no date).

1.2.9 Secondary fermentation and bulk aging

During the secondary fermentation and aging process, which takes three to six months, the fermentation continues slowly. The wine is kept under an airlock to protect the wine from oxidation. Proteins from the grape are broken down and the remaining yeast cells and other fine particles from the grapes are allowed to settle. Potassium bitartrate will also precipitate, a process which can be enhanced by cold stabilization to prevent the appearance of tartrate crystals after bottling. The result of these processes is that the originally cloudy wine becomes clear. The wine can be racked during this process to remove the lees.

The secondary fermentation usually takes place in either large stainless steel vessels with a volume of several cubic meters of wine, or oak barrels, depending on the goals of the winemakers. Unoaked wine is fermented in a barrel made of stainless steel or other material having no influence in the final taste of the wine. Depending on the desired taste, it could be fermented mainly in stainless steel to be briefly put in oak, or have the complete fermentation done in stainless steel. Oak could be added as chips used with a non-wooden barrel instead of a fully wooden barrel. This process is mainly used in cheaper wine.

Amateur winemakers often use glass carboys in the production their wine; these vessels (sometimes called demijohns) have a capacity of 4.5 to 54 liters (1.2–14.3 US gallons). The kind of vessel used depends on the amount of wine that is being made, the grapes being used, and the intentions of the winemaker.

1.2.10 Malolactic fermentation

Malolactic fermentation is carried out by bacteria which metabolize malic acid and produce lactic acid and carbon dioxide. The resultant wine is softer in taste and has greater complexity. The process is used in most red wines and is discretionary for white wines.

1.2.11 Laboratory tests

Whether the wine is aged in tanks or barrels, tests are run periodically in a laboratory to check the status of the wine. Common tests include °Brix, pH, titratable acidity, residual sugar, free or available sulfur, total sulfur, volatile acidity and percent alcohol. These tests are often performed throughout the making of the wine as well as prior to bottling. In response to the results, a winemaker can then decide if more sulfur needs to be added or other slight adjustments before it is bottled.

°Brix is a measure of the soluble solids in the grape juice and represents not only the sugars but also includes many other soluble substances such as salts, acids and tannins, sometimes called Total Soluble Solids (TSS) However, sugar is by far the compound in greatest quantity and so for all practical purposes Brix is a measure of sugar level. The level of sugar in the grapes is important not only because it will determine the final alcohol content of the wine, but also because it is an indirect index of grape maturity. Brix (Bx for short) is measured in grams per hundred milliliters, so 20Bx means that 100ml of juice contains 20g of dissolved compounds. There are other common measures of sugar content of grapes, Specific gravity, Oechsle (Germany) and Beaume (France). The French Beaume (Be for short) has the benefit that one Be gives approximately one percent alcohol. Also one Beaume is equal to 1.8 Brix, that is 1.8 grams of sugar per one hundred milliliters. This helps with deciding how much sugar to add if the juice is low in sugar; to achieve one percent alcohol add 1.8 grams per 100 ml or 18 grams per liter.

This is the process of chaptalization, legal in some countries illegal in others. However, perfectly acceptable for the home winemaker. Generally, for the making of dry table wines a Bx of between 20 and 25 is desirable, this is equivalent to Be of 11 to 14.

A Brix test can be ran either in the lab or out in the field for a quick reference number to see what the sugar content is at. Brix is usually measured with a refractometer whilst the other methods use a hydrometer. Generally, hydrometers are a cheaper alternative. For more accurate use of sugar measurement it should be remembered that all measurements are affected by the temperature at which the reading is made, suppliers of equipment generally will supply correction charts.

Volatile acidity test verifies if there is any steam distillable acids in the wine. Mainly present is acetic acid but lactic, butyric, propionic and formic acids can also be found. Usually the test checks for these acids in a cash still, but there are new methods available such as HPLC, gas chromatography and even enzymatic methods. The amount of volatile acidity found in sound grapes is negligible. It is a by-product of microbial metabolism. It's important to remember that acetic acid bacteria require oxygen to grow. Eliminating any air in wine containers as well as a sulfur dioxide addition will limit their growth. Rejecting moldy grapes will also prevent possible problems associated with acetic acid bacteria. Use of sulfur dioxide and inoculation with a low-V.A. producing strain of *Saccharomyces sp*. may deter acetic acid producing yeast. A relatively new method for removal of volatile acidity from a wine is reverse osmosis. Blending may also help—a wine with high V.A. can be filtered (to remove the microbe responsible) and blended with a low V.A. wine, so that the acetic acid level is below the sensory threshold.

1.2.12 Blending and fining

Different batches of wine can be mixed before bottling in order to achieve the desired taste. The winemaker can correct perceived inadequacies by mixing wines from different grapes and batches that were produced under different conditions. These adjustments can be as simple as adjusting acid or tannin levels, to as complex as blending different varieties or vintages to achieve a consistent taste.

Fining agents are used during winemaking to remove tannins, reduce astringency and remove microscopic particles that could cloud the wines. The winemakers decide on which fining agents are used and these may vary from product to product and even batch to batch (usually depending on the grapes of that particular year) (Vergan wine guide, 2009).

Gelatin has been used in winemaking for centuries and is recognized as a traditional method for wine fining, or clarifying. Generally no gelatin remains in the wine because it reacts with the wine components, as it clarifies, and forms a sediment which is removed by filtration prior to bottling.

Besides gelatin, other fining agents for wine are often derived from animal and fish products, such as micronized potassium casseinate (casein is milk protein), egg whites, egg albumin, bone char, bull's blood, isinglass (Sturgeon bladder), PVPP (a dairy derivative protein), lysozyme, and skim milk powder (Vergan wine guide, 2009).

Non-animal-based filtering agents are also often used, such as bentonite (a volcanic clay-based filter), diatomaceous earth, cellulose pads, paper filters and membrane filters (thin films of plastic polymer material having uniformly sized holes).

1.2.13 Preservatives

The most common preservative used in winemaking is sulfur dioxide. Another useful preservative is potassium sorbate.

Sulfur dioxide has two primary actions, firstly it is an anti microbial agent and secondly an antioxidant agent. In the making of white wine it can be added prior to fermentation and immediately after alcoholic fermentation is complete. If added after alcoholic ferment it will have the effect of preventing or stopping malolactic fermentation, bacterial spoilage and help protect against the damaging effects of oxygen. Additions of up to 100 mg per liter (of sulfur dioxide) can be added, but the available or free sulfur dioxide should be measured by the aspiration method and adjusted to 30 mg per liter. Available sulfur dioxide should be maintained at this level until bottling. For rose wines smaller additions should be made and the available level should be no more than 30 mg per liter.

In the making of red wine sulfur dioxide may be used at high levels (100 mg per liter) prior to fermentation to assist stabilize color otherwise it is used at the end of malolactic ferment and performs the same functions as in white wine. However, small additions (say 20 mg per liter) should be used to avoid bleaching red pigments and the maintenance level should be about 20 mg per liter. Furthermore, small additions (say 20 mg per liter) may be made to red wine after alcoholic fermentation and before malolactic fermentation to over come minor oxidation and prevent the growth of acetic acid bacteria. Without the use of sulfur dioxide, wines can readily suffer bacterial spoilage no matter how hygienic the winemaking practice.

Potassium sorbate is effective for the control of fungal growth, including yeast, especially for sweet wines in bottle. However, one potential hazard is the metabolism of sorbate to geraniol a potent and very unpleasant by-product. To avoid this either the wine must be sterile bottled or contain enough sulfur dioxide to inhibit the growth of bacteria.

1.2.14 Filtration

Filtration in winemaking is used to accomplish two objectives, clarification and microbial stabilization. In clarification, large particles that affect the visual appearance of the wine are removed. In microbial stabilization, organisms that affect the stability of the wine are removed therefore reducing the likelihood of re-fermentation or spoilage.

The process of clarification is concerned with the removal of particles; those larger than 5–10 micrometers for coarse polishing, particles larger than 1–4 micrometers for clarifying or polishing. Microbial stabilization requires a filtration of at least 0.65 micrometers. However, filtration at this level may lighten a wines color and body. Microbial stabilization does not imply sterility. It simply means that a significant amount of yeast and bacteria have been removed.

1.2.15 Bottling

A final dose of sulfite is added to help preservation of the wine and prevent unwanted fermentation in the bottle. The wine bottles then are traditionally sealed with a cork, although alternative wine closures such as synthetic corks and screwcaps, which are less subject to cork taint, are becoming increasingly popular (Tinney, 2006).

1.2.16 Wine aging

Despite the well known saying that "All wine improves with age", only a few wines will actually have the ability to significantly improve with age. It was reported that only around the top 10% of all red wine and top 5% of all white wines can improve significantly enough with ageing to make drinking more enjoyable at 5 years of age than at 1 year of age. Additionally, only the top 1% of all wine has the ability to improve significantly after more than a decade. It is beleaved that more wine is consumed too old, rather than too young, and that the great majority of wines start to lose appeal and fruitiness after 6 months in the bottle (Jancis, 2006 and Blog Cellarer, no date).

In general, wines with a low pH (such as Pinot noir and Sangiovese) have a greater capability of aging. With red wines, a high level of flavor compounds, such as phenolics (most notably tannins), will increase the likelihood that a wine will be able to age. Wines with high levels of phenolic compound include Cabernet Sauvignon, Nebbiolo and Syrah (Jancis, 2006). The white wines with the longest aging potential tends to be those with a high amount of extract and acidity. The acidity in white wines plays a similar role that tannins have with red wines in acting as a preservative. The process of making white wines, which include little to no skin contact, means that white wines have a significantly fewer amounts of phenolic compounds (though barrel fermentation and oak aging can impart some phenols). Similarly, the minimal skin contact with rosé wine limits their aging potential (Jancis, 2006 and Blog Cellarer, no date).

After aging at the winery most wood-aged wines such as ports, sherries, vins doux naturels, vins de liqueur, basic level ice wines and sparkling wines are bottled when the producer feels that they are ready to be consumed. These wines are ready to drink upon release and will not benefit much from aging. Vintage Ports and other bottled-aged Ports & Sherries will benefit from some additional aging, as can vintage Champagne (Jancis, 2006). In 2009, a 184-year-old bottle of Perrier-Jouët was opened and tasted, still drinkable, with notes of "truffles and caramel", according to the experts (Vergan wine guide, 2009 and BBC News, 2009).

Many factors and influences effect wine aging. The ratio of sugars, acids and phenolics to water is a key determination of how well a wine can age. The less water in the grapes prior to harvest, the more likely the resulting wine will have some aging potential. Grape variety, climate, vintage and viticultural practice come into play here. Grape varieties with thicker skins, from a dry growing season where little irrigation was used and yields were kept low will have less water and a higher ratio of sugar, acids and phenolics. The process of making Eisweins, where water is removed from the grape during pressing as frozen ice crystals, has a similar effect of decreasing the amount of water and increasing aging potential (Jancis, 2006 and Blog Cellarer, no date).

In winemaking, the duration of maceration or skin contact will influence how much phenolic compounds are leached from skins into the wine. Pigmented tannins, anthocyanins, colloids, tannin-polysaccharides and tannin-proteins not only influence a wine's resulting color but also act as preservatives. During fermentation adjustment to a wine's acid levels can be made with wines with lower pH having more aging potential. Exposure to oak either during fermentation or after during barrel aging will introduce more phenolic compounds to the wines. Prior to bottling, excessive fining or filtering of the wine could strip the wine of some phenolic solids and may lessen a wine's ability to age (Jancis, 2006).

The storage condition of the bottled wine will influence a wine's aging. Vibrations and heat fluctuations can hasten a wine's deterioration and cause adverse effect on the wines. In general, a wine has a greater potential to develop complexity and more aromatic bouquet if it is allowed to age slowly in a relatively cool environment. The lower the temperature, the more slowly a wine develops. On average, the rate of chemical reactions in wine double with each 18°F (8°C) increase in temperature. Some wine experts, recommend keeping wine intended for aging in a cool area with a constant temperature around 55°F (13°C). Wine can be stored at temperatures as high as 69°F (20°C) without long term negative effect. Wine could be exposed to temperatures as high as 120°F (49°C) for a few hours and not be damaged. However, most experts believe that extreme temperature fluctuations (such as repeated transferring a wine from a warm room to a cool refrigerator) would be detrimental to the wine. The ultra-violet rays of direct sunlight should also be avoided because of the free radicals that can develop in the wine and result in oxidation (Tinney, 2006 and MacNeil, 2001).

Wines packaged in large format bottles, such as magnums and 3 liter Jeroboams, seem to age more slowly than wines packaged in regular 750 ml bottles or half bottles. This may be because of the greater proportion of oxygen exposed to the wine during the bottling process. The advent of alternative wine closures to cork, such as screw caps and synthetic corks have opened up recent discussions on the aging potential of wines sealed with these alternative closures. Currently there is no conclusive results and the topic is the subject of ongoing research (Jancis, 2006).

Bottle sickness is also some effects during wine aging. One of the short-term aging needs of wine is a period where the wine is considered "sick" due to the trauma and volatility of the bottling experience. During bottling some oxygen is exposed to the wine, causing a domino effect of chemical reaction with various components of the wine. The time it takes for the wine to settle down and have the oxygen fully dissolve and integrate with the wine is considered its period of "bottle shock". During this time the wine could taste drastically different than it did prior to bottling or how it will taste after the wine has settled. While many modern bottling lines try to treat the wine as gently as possible and utilize inert gases to minimize the amount of oxygen exposure, all wine goes through some period of bottle shock. The length of this period will vary with each individual wine (Jancis, 2006 and Blog Cellarer, no date).

During the course of aging a wine may slip into a "dumb phase" where its aromas and flavors are very muted. In Bordeaux this phase is called the age ingrat or "difficult age" and is likened to a teenager going through adolescence. The cause or length of time that this "dumb phase" will last is not yet fully understood and seems to vary from bottle to bottle (Tinney, 2006 and MacNeil, 2001).

As red wine ages, the harsh tannins of its youth gradually give way to a softer mouthfeel. An inky dark color will eventually fade to a light brick red. These changes occur due to the complex chemical reactions of the phenolic compounds of the wine. In processes that begin during fermentation and continue after bottle, these compounds bind together and aggregate. Eventually these particles reach a certain size where they are too large to stay suspended in the solution and the precipitate out. The presence of visible sediment in a bottle will usually indicate a mature wine. The resulting wine, with this loss of tannins and pigment, will have a paler color and taste softer, less astringent. The sediment, while harmless, can have an unpleasant taste and is often separated from the wine by decanting (Jancis, 2006 and Blog Cellarer, no date).

During the aging process, the perception of a wine's acidity may change even though the total measurable amount of acidity is more or less constant throughout a wine's life. This is due to the esterification of the acids, combining with alcohols in complex array to form esters. In addition to making a wine taste less acidic, these esters introduce a range of possible aromas. Other chemical processes that occur during aging include the hydrolysis of flavor precursors which detach themselves from glucose molecules and introduce new flavor notes in the older wine. The interaction of certain phenolics develop what is known as tertiary aromas which are different from the primary aromas that are derived from the grape and during fermentation (Jancis, 2006).

As a wine starts to mature, its bouquet will become more developed and multi-layered. While a taster may be able to pick out a few fruit notes in a young wine, a more complex wine will have several distinct fruit, floral, earthy, mineral and oak derived notes. Eventually the wine will reach a point of maturity, when it is said to be at its "peak". This is the point when the wine has the maximum amount of complexity, most pleasing mouthfeel and softening of tannins and has not yet started to decay. If a wine is aged for too long, it will start to descend into decrepitude where the fruit tastes hollow and weak while the wine's acidity becomes dominant (Jancis, 2006).

1.2.17 Artificial aging

There is a long history of man using artificial means to try to accelerate the natural aging process. In Ancient Rome a smoke chamber known as a fumarium was used to enhance the flavor of wine through artificial aging. Amphorae were placed in the chamber, which was built on top of a heated hearth, in order to impart a smoky flavor in the wine that also seemed to sharpen the acidity. The wine would sometimes come out of the fumarium with a paler color just like aged wine (Hugh, 1989). Modern winemaking techniques like micro-oxygenation can have the side effect of artificially aging the wine. In the production of Madeira and rancio wines, the wines are deliberately exposed to excessive temperatures to accelerate the maturation of the wine. Other techniques used to artificially age wine (with inconclusive results on their effectiveness) include shaking the wine, exposing it to radiation, magnetism or ultra-sonic waves (Jancis, 2006). More recently, experiments with artificial aging through high-voltage electricity have produced results above the remaining techniques, as assessed by a panel of wine tasters (New Scientist, no date).

1.2.18 Oak Aging

The use of oak in wine plays a significant role in winemaking and can have a profound effect on the resulting wine, affecting the color, flavor, tannin profile and texture of the wine. Oak can come into contact with wine in the form of a barrel during the fermentation or aging periods. It can be introduced to the wine in the form of free-floating oak chips or as wood staves (or sticks) added to wine in a fermentation vessel like stainless steel. Oak introduced in the form of a wine barrel can impart other qualities to the wine through the process of evaporation and low level exposure to oxygen (Jancis, 2006).

In early wine history the amphora was the vessel of choice for the storage and transportation of wine. Due to the perishable nature of wood material it is difficult to trace the usage of barrels in history. The Greek historian Herodotus noted that ancient Mesopotamians used barrels made of palm wood to transport wine along the Euphrates. Palm is a difficult material to bend and fashion into barrels, however, and wine merchants in different regions experimented with different wood styles to find a better wood source (Blog Cellarer, no date and Hugh, 1989). The use of oak has been prevalent in winemaking for at least two millennia, first coming into widespread use during the Roman empire. In time, winemakers discovered that beyond just storage convenience that wine kept in oak barrels took on properties that improved the wine by making it softer and in some cases better-tasting (Vergan wine guide, 2009 and MacNeil, 2001). Robert Mondavi is credited with expanding the knowledge of winemakers in the United States about the different types of oak and barrel styles through his experimentation in the 1960s & 1970s (Tinney, 2006 and Hugh, 1989).

The porous nature of an oak barrel allows some levels of evaporation and oxygenation to occur in wine but typically not at levels that would cause oxidation or spoilage of the wine. In a year, the typical 59-gallon barrel can lose anywhere from 5 1/2 to 6 1/2 gallons of wine through the course of evaporation. This evaporation (of mostly alcohol and water) allows the wine to concentrate its flavor and aroma compounds. Small amounts of oxygen are allowed to pass through the barrel and acts as a softening agent upon the tannins of the wine (Vergan wine guide, 2009 and MacNeil, 2001).

The chemical properties of oak itself can have a profound effect on the wine. Phenols within the wood interact with the wine to produce vanilla type flavors and can give the impression of tea notes or sweetness. The degree of "toast" on the barrel can also impart different properties affecting the tannin levels of the wine as well as the aggressive wood flavors (MacNeil, 2001). The hydrolyzable tannins present in wood, known as ellagitannins, are derived from lignin structures in the wood. They help protect the wine from oxidation and reduction (Jancis, 2006).

Wines can be barrel fermented in oak or they can be placed in oak after fermentation for a period of aging or maturation. Wine that is matured in oak receives more of the oak flavors and properties than wine that is fermented in oak. This is because yeast cells interact with and "latch on" to the oak components. When the dead yeast cells are removed from the wine as lees some of these oak properties go with them (Jancis, 2006 and MacNeil, 2001). A characteristic of white wines that are fermented in oak include a pale color with an extra silky texture. White wines that are fermented in steel and then matured in oak will have a darker coloring due to the heavy phenolic compounds that are still present (Jancis, 2006). Flavor notes that are common descriptions of wines exposed to oak include caramel, cream, smoke, spice and vanilla. Chardonnay is a variety that has very distinct flavor profiles when fermented in oak that include coconut, cinnamon and cloves notes. The "toastiness" of the barrel can bring out varying degrees of mocha and toffee notes in red wine (Wine spectator(a), no date).

The length of time that a wine spends in the barrel is dependent on the varietals and style of wine that the winemaker wishes to make. The majority of oak flavoring is imparted in the first few months that the wine is in contact with oak but a longer term exposure can affect the wine through the light aeration that the barrel allows which helps to precipitate the phenolic compounds and quickens the aging process of the wine (Jancis, 2006). New World Pinot noir may spend less than a year in oak. Premium Cabernet Sauvignon may spend two years. The very tannic Nebbiolo grape may spend four or more years in oak. High end Rioja producers will sometimes age their wines up to ten years in American oak to get a desired earthy, vanilla character (Jancis, 2006 and MacNeil, 2001).

The species of oak typically used for American oak production is the Quercus alba which is a white oak species that is characterized by its relatively fast growth, wider grains and lower wood tannins. It is found in most of the Eastern United States as well as Missouri, Minnesota and Wisconsin where many wine barrels are from. In Oregon the Quercus garryana white oak has started to gain usage due to its closer similarities to European oak. In France, the main winemaking oak species is the Quercus petraea which is known for tighter grain, high tannins and lower aromatics than its American oak counterpart. French oak typically comes from one or more primary forests: Allier, Limousin, Nevers, Troncais and Vosges. The wood from each of these forests has slightly different characteristics. Many winemakers utilize barrels made from different cooperages, regions and degrees of toasting in blending their wines to enhance the complexity of the resulting wine (MacNeil, 2001 and Stevenson, 2005).

The tighter grain of French oak allows for a more gradual integration of flavors in the wine.Italian winemakers have had a long history of using Slovenian oak from the Quercus robur which is known for its tight grain, low aromatics and medium level tannins. Prior to the Russian Revolution, Quercus petraea oak from the Baltic states was the most highly sought after wood for French winemaking (Jancis, 2006 and Hugh, 1989). Today Russian oak from the Adygey region along the Black Sea is being explored by French winemakers as a cheaper alternative to French oak (New Scientist, no date and Wine spectator(b), no date). Canadian wineries have been experimenting with the use of Canadian oak, which proponents describe as a middle ground between American and French oak even though it is the same species as American oak (Jancis, 2006 and Wine spectator(b), no date).

Oak trees are typically between 80-120 years old prior to harvesting with the ideal conditions being a cool climate in a dense forest region that gives the trees opportunity to mature slowly and develop a tighter grain. Typically one tree can provide enough wood for two 59 gallon barrels. The trees are typically harvested in the winter months when there is less sap in the trunk (Jancis, 2006 and Hugh, 1989).

American oak tends to be more intensely flavoured than French oak with more sweet and vanilla overtones due to the American oak having two to four times as many lactones (White Wines, New Barrels: The taste of new oak gains favor worldwide, 2009). Winemakers that prefer American oak typically use them for bold, powerful reds or warm climate Chardonnays. Besides being derived from different species, a major difference between American and French comes from the preparation of the oak. The tighter grain and less watertight nature of French oak encourages coopers to split the wood along the grain rather than saw. French oak is then traditionally aged or "seasoned" for at least two years whereas American coopers will often use a kiln-dry method to season the wood (Jancis, 2006 and Hugh, 1989). Long periods of outdoor season has a mellowing effect on the oak that kiln-dry methods have difficulties replicating (Wine spectator, no date). The sawing, rather than splitting, of American oak also enhances the differences between the two styles due to the rupture of the xylem cells in the wood which releases many of the vanillin aromatics and lactones responsible for characteristics like the coconut notes (Hugh, 1989 and Stevenson, 2005).

1.2.19 Barrel alternatives

Although oak barrels have long been used by winemakers, many wineries now use oak wood chips for aging wine more quickly and also adding desired woody aromas along with butter and vanilla flavors. Oak chips can be added during fermentation or during aging. In the latter case, they are generally placed into fabric sacks and placed into the aging wine. The diversity of chips available gives winemakers numerous options. Oak chips have the benefit of imparting intense oak flavoring in a matter of weeks while traditional oak barrels would need a year or more to convey similar intensity. Critics claim that the oak flavoring from chips tend to be onedimensional and skewed towards the vanilla extract with the wines still lacking some of the physical benefits that barrel oak imparts (Hugh, 1989 and Wine spectator(d), 2009). The use of oak powder is also less common than chips, although they are a very practical alternative if oak character is to be introduced during fermentation. Oak planks or staves are sometimes used, either during fermentation or aging. Wines made from these barrel alternatives typically do not age as well as wines that are matured in barrels. Improvements in micro-oxygenation has allowed winemakers to better mimic the gentle aeration of oak barrels in stainless steel tanks with oak chips (Jancis, 2006).

Prior to 2006, the practice of using oak chips was outlawed in the European Union (Jancis, 2006 and MacNeil, 2001). In 1999, the Bordeaux court of appeals fined four wineries, including third growth Chateau Giscours, more than $13,000 USD for the use of oak chips in their wine (Wine spectator(d), no date).

1.2.20 Oak Composition in Wine Aging (Ross, 1992 and Chatonnet, 1998)

The major constituents in barrels can be grouped into non-volatile and volatile classes. The non-volatile compounds include cellulose, hemicellulose, lignin, and tannins; presented in to Table 1.1 The volatile classes of compounds include eugenol, vanillin, syringaldehyde, sinapaldehyde, α-methyl-α-octalactone, furfurals, and isoprenoids. It is the extraction of these compounds from the barrel that contribute to the enhancement of the aroma profile of the wine.

Table 1.1 Major Constituents in Oak.

Compound	Amonunt	Example	Byproducts
Cellulose	40-45%	Glucose Polymers	Levoglucosan
Hemicellulose	20-25%	Xylose, Arabinose, Goucose, Mannose	Furfural, Maltol, Cycotene
Lignin	25-35%	p-Coumaryl, Coniferyl, sinapyl	Guiacol, Vanillin, Eugenol
Tannin	5-10%	Ellagitanin	Glucose+Gallic acid
Other	0.1-0.5%	Terpenes, Lipids	-

Reference: Chatonnet, 1998.

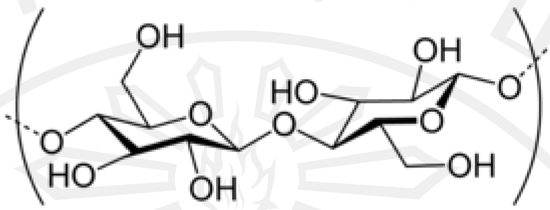


Figure 1.1 Structure of Cellulose

Reference: http://en.wikipedia.org/wiki/Cellulose

Cellulose is the major structural component in wood and is composed of a polymer of a glucose polysaccharide as is illustrated. It consists of up to 10,000 units of an anhydro-glucopyranose $(C_6H_{10}O_5)_n$ structure linked through a α-1,4-glucosidic bond. Celluslose, however is not extracted in winemaking, but may play a role in the aging of whiskey where heavy toasting and charring of the barrel may promote sufficient degradation and thereby facilitate extraction.

Conversely, the hemicellulose class of compounds have a major impact on sensory attributes in oak aged wines. Hemicellulose comprises up to 35% of the dry weight of wood and is a polymer of sugars. The primary sugars found in hemicellulose include: pentoses, like xylose and arabinose, and hexoses, like glucose, galactose, and mannose. Xylose is the most predominant polysaccharide found in oak, while glucose and arabninose are the least concentrated. In addition, hemicellulose hydrogen bonds with cellulose thereby increasing the overall strength of the wood. Some common hemicelluloses include: pectins, xylans, starch, and galactans. During the toasting process, hemicellulose is partially decomposed into smaller constituents and can consequently participate in chemical reactions. This process ultimately yields compounds, like furfural, maltol, cyclotene and ethoxylactone, for example. These aromatic compounds are characterized as being toasty and caramel aromas. In addition, in the presence of amino acids and heat, hemicellulose can form additional volatile compounds through Maillard reactions. In this process, amino acids react with sugars to form a cyclic structure known as an Amadori intermediate. This intermediary can subsequently be hydrolyzed to form compounds such as maltol, hydroxymaltol, dihydromaltol, and isomaltol. With the exception of isomaltol which has no aromatic attributes, all other compounds are characterized as toast and caramel in aroma. Interestingly, in a report by Hodge, it is speculated that the following enolic group was specifically responsible for the toasty aroma of these compounds: H_3C-C=C-C-R'. Note that isomaltol does not have this enolic group and thus is not aromatic.

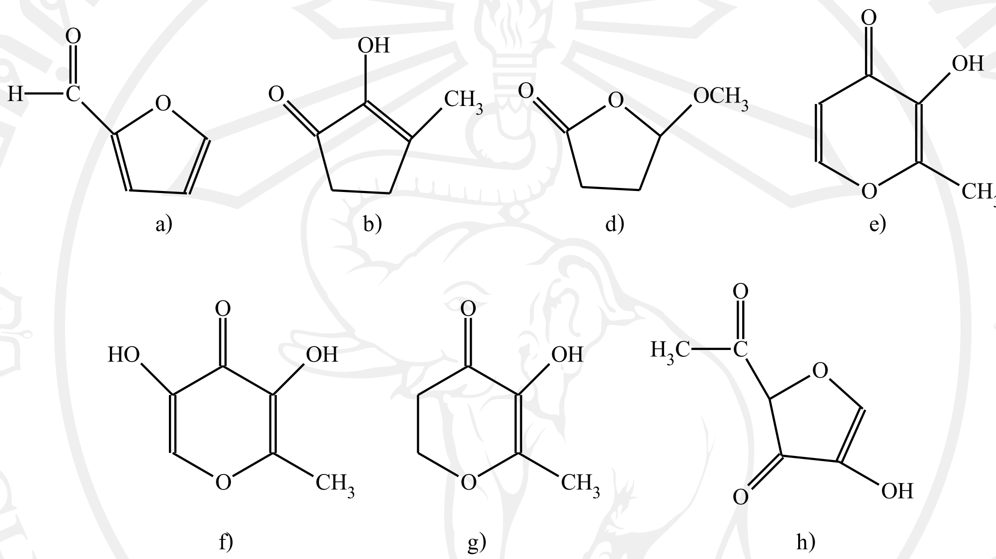


Figure 1.2 Structure of a) Furfural; b) Cyclotene; c) Ethoxylactone; d) Maltol; e) Hydroxymaltol; f) Dihydroaltol and g) Isomaltol

Lignin comprises up to 35% of the wood and forms a structure similar to a crystal lattice that provides support to other components in the wood. The breakdown of lignin provides the building blocks for many of the aromatic compounds found in oak aged wines. In fact, the majority of aromatic compounds that result from oak contact are produced by lignin degradation. Lignin is a polymer of hydroxycinnamyl alcohols, such as p-coumaryl, coniferyl, and sinapyl alcohols. Like hemicellulose, the degree of toasting, and to a lesser extent seasoning, will determine the degree to which Lignin is broken down into aromatic compounds. The effects of seasoning and toasting will be discussed in detail later.

Lignin degradation products can be classified into three basic groups: lactones, aldehydic phenols, and volatile phenols. Of these the lactones are both the largest group, accounting for 80% of the total extracted aromatic compounds, and the most important sensorily. Aromatic compounds from the aldehydic and aromatic phenols are often found at or below their sensory threshold. However, synergistic effects create in a complex aroma matrix in which it is possible that compounds below their perception threshold nevertheless impact the aroma.

Cis and *trans* α-methyl-α-octalactone are the most frequently encountered of the lactones. They occur in European oak in the ratio of 77% *cis* and 23% *trans*. American oak contains more of the *cis* isomer. These compounds are usually found above their sensory threshold and are frequently described as coconut, woody and vanilla. Aldehydic phenols are formed when lignin degradation products are modified by a mechanism such as a Maillard reaction. Examples include vanillin, syringaldehyde, coniferaldehyde and sinapaldehyde. Volatile phenols are generally produced by thermal degradation of aldehydic phenols. Furfural is one of the most important sensorily, contributing a caramelized aroma. Eugenol produces a spicy, clove like aroma while guaiacol is perceived as smoky.

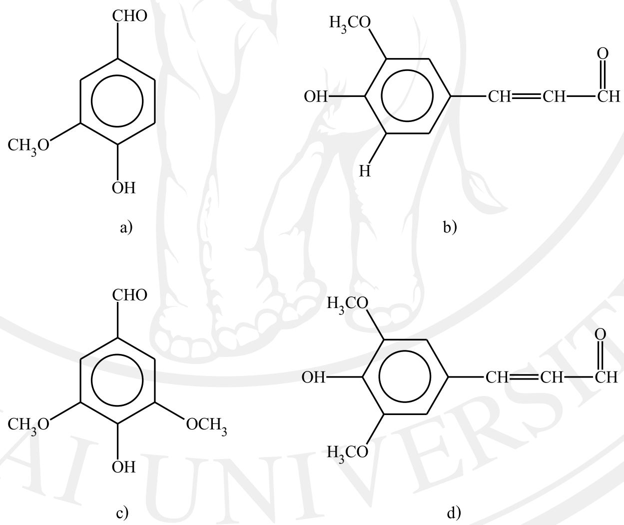
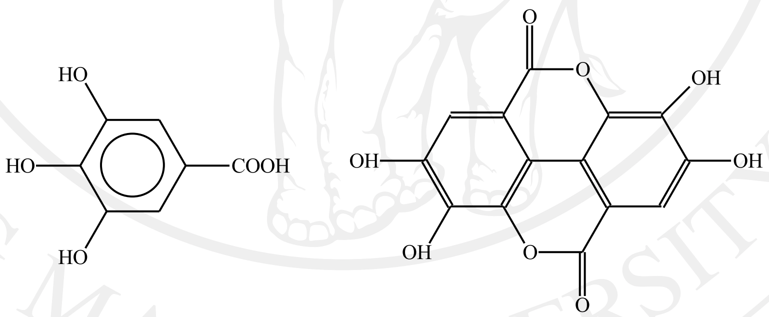


Figure 1.3 Structure of a) Vanillin; b) Syringaldehyde; c) Coniferaldehyde and d) Sinapaldehyde

The concentration of these volatile compounds in wine may change over time due to interactions with other substances. For example, the vanillin concentration in a white wine was one third of a control model wine that had no lees contact. Also, vanillyl alcohol concentration in the sur lees white wine went up. Although the exact mechanism is uncertain, it was clear that enzymatic activity related to the yeast had converted the vanillin to vanillyl alcohol. Two other aromatic compounds were investigated in this study. Furfural was converted to furyl alcohol during malolactic fermentation and eugenol concentration was noted to go down after bottling. The later was thought to possibly be the result of absorption in the cork.

Although many of the compounds are found below their threshold, it is thought that a complex aroma matrix exists that includes the aromatic lignin degradation products and to a lesser degree hemicellulose degradation products, norisoprenoids and other terpenoids. Taken together, these compounds typically result in aromas described as toasty, toasted coconut, nutty, oaky, spicey, caramel, and vanilla.

Tannins are the final class of major components in oak and are present on the order of 5-10% of the total dry weight of wood. Tannins are primarily esters of carboxylic acids and sugars and are composed of non-flavonoid polymers in the form of hydrolyzable tannins. Gallitannins and ellagitannins, for example, are composed of glucose and gallic or ellagic acid (dimer of gallic acid), respectively, are the predominant tannins in oak cooperage. In addition, oak is rich in ellagitannins.



a) b)

Figure 1.4 Structure of a) Gallic acid and b) Ellagic acid.

Seven species of ellagitannins have been identified and are classified as monomers or dimers. Some monomeric forms of ellagitannins include castalagin and vescalagin, and are depicted below. In addition, monomeric ellagitannins can have a sugar moiety at the R1 position yielding grandinin. These types of tannins can dimerize and form higher structures named roburin with 4 observed forms. Simple dimers of where R1 can be -OH or R2 -OH are known as roburin D and roburin A, respectively. Roburin B and C also exist where R2 is either lyxose or xylose, respectively. To some degree the extraction of these compounds are affected by toasting, but are primarily affected by wine pH and ethanol. At wine pH, hydrolyzable ellagitannins are reduced to their basic components of glucose and gallic acid.

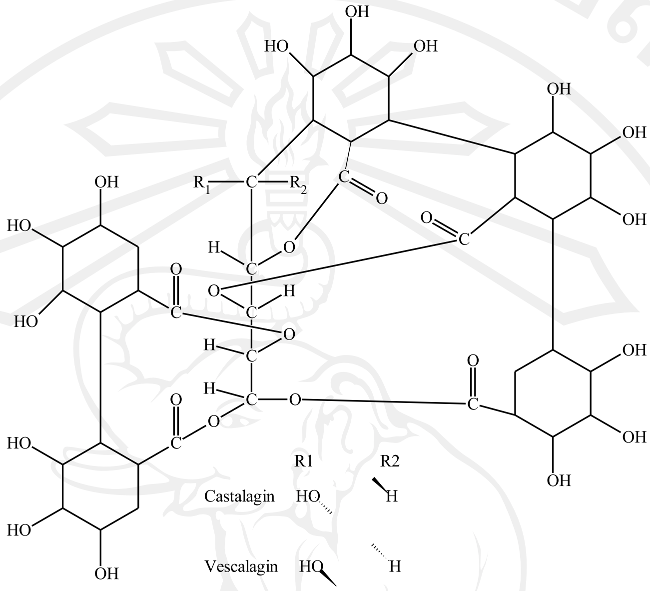


Figure 1.5 Structure of Ellagitannins

Reference: http://en.wikipedia.org/wiki/Ellagitannin

Since tannins represent approximately 5-10% of the dry weight of wood, little evidence exists that correlates an increase in astringency due to barrel-aging. In one year in a standard barrique (225L) barrel up to 300 mg/L GAE of phenols are extracted into the wine. Experiments conducted by Pocock, et al., suggest that the contribution of oak tannins to overall astringency is low. Analysis of oak-aged wines by GC and Folin assays indicate that levels of tannins were at or near thresholds, indicating that there was little addition of tannin. Duo-trio tests were also performed and resulted in no significant differences with respect to astringency. Thus, oak-aging of wine has a very little effect on the overall astringency of a given wine.

1.2.21 Other wood types

Throughout history other wood types, including chestnut, pine, redwood, and acacia, have been used in crafting winemaking vessels, particular large fermentation vats. However none of these wood types possess the compatibility with wine that oak has demonstrated in combining its water tight, yet slightly porous, storage capabilities with the unique flavor and texture characteristic that it can impart to the wine that it is in contact with (Jancis, 2006 and Wine spectator(b), no date). Chestnut is very high in tannins and is too porous as a storage barrel and must be coated with paraffin to prevent excessive wine loss through evaporation. Redwood is too rigid to bend into the smaller barrel shapes and imparts an unpleasant flavor. Acacia imparts a yellow tint to the wine. Other hardwoods like apple and cherry wood have an off putting smell (Stevenson, 2005 and Carrillo, *et. al.*, 2006). Austrian winemakers have a history of using Acacia barrels. Historically, chestnut was used by Beaujolais, Italian and Portuguese wine makers (Jancis, 2006). Some Rhone winemakers still use paraffin coated chestnut barrels but the coating minimizes any effect from the wood making its function similar to a neutral concrete vessel. In Chile there are traditions for using barrel made of rauli wood but it is beginning to fall out of favor due to the musky scent it imparts on wine (Stevenson, 2005 and Wine spectator(b), 2009).

1.3 Aroma of wine

It is through the aromas of wine that wine is actually tasted. The human tongue is limited to the primary tastes perceived by taste receptors on the tongue-acidity, bitterness, saltiness, sweetness and umami. The wide array of fruit, earthy, floral, herbal, mineral and woody flavor perceived in wine are derived from aroma notes interpreted by the olfactory bulb. In wine tasting, wine is often smelled before being drunk in order to identify some components of the wine that may be present. Different terms are used to describe what is being smelled. The most basic term is aroma which generally refers to a "pleasant" smell as opposed to odor which refers to an unpleasant smell or possible wine fault. The term aroma maybe further distinguished from bouquet which generally refers to the smells that arise from the chemical reactions of fermentation and aging of the wine (Jancis, 2006 and Blog cellarer, no date).

1.3.1 Components of a wine's aroma (Jancis, 2006 and Vergan wine guide, 2009)

Within wine there are volatile and non-volatile compounds that contributes to the make up of a wine's aroma. During the fermentation and for the first few months of a wine's existence, chemical reactions among these compounds occur frequently and a wine's aroma will change more rapidly during this period than at any other point. As a wine ages and mature, changes and developments in aroma will continue to take place but at a slower and more gradual pace. Volatile aroma compounds are present in the skin and juice of a grape berry and will vary in composition according to the individual grape variety. It is theorized that the Vitis vine developed these compounds as a evolutionary tool to aid in procreation by attracting insects to assist with pollination and birds and other animals to eat the berries and disperse the seeds. The diverse spectrum of aromas associated with individual grape varieties is a reflection of the vine's adaptation to ecological conditions and competition among other plants.

The majority of volatile compounds responsible for aroma combine with sugars in the wine to form odorless glycosides. Through the process of hydrolysis, caused by enzymes or acids in the wine, they revert into an aromatic form. The act of tasting wine is essentially the act of smelling these vaporized aroma compounds. Olfactory receptors cells, each sensitive to a different aromas, pick up these compounds and transfers the information to the brain by way of the olfactory bulb (MacNeil, 2001 and Tinney, 2006). In the 1980s there was renewed focus in studying the correlation between aroma/flavor compounds in grapes and the resulting quality of wine. Scientists were able to use gas chromatograph-mass spectrometers to identify volatile aroma compounds in various grape varieties.

Study of the compounds responsible for aroma and flavor, as well as their correlation with a wine's quality, is ongoing. As understanding of these compounds grows, there is concern that wines in the future could be "manipulated" through the use of chemical additives to add complexity and additional aromas to wine (such as creating a manufactured perfume) . In 2004, a winery in South Africa was found to have added illegal flavoring to their Sauvignon blanc to enhance the aroma. Viticultural studies have focused on how aroma compounds develop in the grapes during the annual growth cycle of the vine and how viticultural techniques such as canopy management may contribute to developing desirable aromatics in the wine.

1.3.2 Aroma compounds identification (Jancis, 2006 and Vergan wine guide, 2009)

Some of the identified aroma compound include the following:

i) Methoxypyrazine-grassy, herbaceous aroma compound associated with Cabernet Sauvignon and Sauvignon blanc.

ii) Monoterpenes-responsible for the floral aromatics of varieties like Gewürztraminer, Muscat and Riesling. Includes geraniol, linalool and nerol.

iii) Norisoprenoids-Carotenoid derived aromatic compound that includes megastigmatrienone which produces some of the spice notes associated with Chardonnay and zingerone responsible for the different spice notes associated with Syrah. Other norisoprenoids include raspberry ketone which produces some of the raspberry aromas associated with red wine, damascenone which produces some of the rose oil aromas associated with Pinot noir and vanillin.

iv) Thiols-sulfur contain compounds that can produce an aroma of garlic and onion that is considered a wine fault (mercaptans). They have also been found to contribute to some of the varietal aromas associated with Cabernet Sauvignon, Gewürztraminer, Merlot, Muscat, Petit Manseng, Pinot blanc, Pinot gris, Riesling, Scheurebe, Semillon and Sylvaner.

Some of the aromas perceived in wine are from esters created by the reaction of acids and alcohol in the wine. Esters can develop during fermentation, with the influence of yeast, or later during aging by chemical reactions. The precise yeast strain used during fermentation and temperature are two of the strongest indicators of what kind of esters will develop and helps explain partially why Chardonnay grown in the same vineyard but made by two different producers could have different aromatics. During bottle aging hydrogen ions, found in higher concentration in low pH (high acid) wines, serves as a catalyst in the formation of esters from acids and alcohols present in the wine. However, at the same time these hydrogen ions encourage esters to also split apart back into acids and alcohols. These two counter-balancing acts gradually inch a wine closer to a state of equilibrium where there is equal parts alcohol, acids, esters and water (a by product of the reactions). During this period the ester influenced bouquet of the wine is constantly changing due to the concentration, formulation and splitting of different esters. This is partly the reason why a wine will have one set of aromas at one time and other aromas later in its life.

1.3.3 Wine tasting (MacNeil, 2001 and Tinney, 2006)

The sense of smell and detecting the aromas in wine are the primary means through which wine is tasted and evaluated. Prior to tasting the wine, wine drinkers will often smell the wine in the glass (French Barrel maker Turns to Russian Oak, 2009). Large bowl glasses with tapered openings, some of which are specifically designed to enhance aromatics of different wines, can assist in capturing more aromatics within the glass for the drinker to detect. Wines served at warmer temperature will be more aromatic than wine at cooler due to heat abilities to increase the volatility of aromatic compounds in the wine. Swirling, or aerating, the wine will introduce more air molecules into the wine which can capture the aroma molecules and carry them up to the nose. Some subtle aromatics can be overwhelmed by more dominant aromatics that are arise after swirling so most professional tasters will sniff the wine briefly first before swirling. The closer the nose is to the wine, even right inside the glass, the greater chances of aromatics being captured. A series of short, quick sniffs versus one long inhale will also maximize the likelihood of aromatics being detected. The human nose starts to "fatigue" after around six seconds and so a pause maybe needed between sniffs.

When wine is sipped, it is warmed in the mouth and mixes with saliva to vaporize the volatile aroma compounds. These compounds are then inhaled "retro-nasally" through the back of the mouth to where it is received by nearly five million nerve cells. The average human can be trained to distinguish thousands of smells but can usually only name a handful at a time when presented with many aromas. This phenomenon, known as the "tip of the nose phenomenon", is countered when a person is giving a list of possible choices through which they can often positively identify the aroma. Professional wine tasters will often mentally cycle through a list of potential aromas (and may use visual aids like the aroma wheel) until one choice stands out and can be identified in the wine.

Detecting an aroma is only part of wine tasting. The next step is to describe or communicate what that aroma is and it is in this step that the subjective nature of wine tasting appears. Different individuals have their own unique way of describing familiar scents and aromas based on their own unique experiences. Furthermore there are varying levels of sensitivity and recognition thresholds among humans of some aromatic compounds. This is why one taster may describe different aromas and flavors than another taster sampling the very same wine (Wine spectator, no date).

1.4 Wood types used in this research

1.4.1 Longan (Anan, n.d)

Longan (*Dimocarpus longan)* is handsome, erect, 9-12 m in height and 14 m in width, with rough-barked trunk 76.2 cm thick and long, spreading, slightly drooping, heavily foliaged branches. Leaves evergreen, alternate, paripinnate, 4-10 opposite leaflets, elliptic, ovate-oblong or lanceolate, blunt-tipped; 10-20 cm long and 3.5-5 cm wide; leathery, wavy, glossy-green on the upper surface, minutely hairy and grayish green beneath. New growth is wine-colored and showy. Flowers pale-yellow, 5-6-petalled, hairy-stalked, larger than those of the closely related species, Litchi chinensis (lychee), are borne in upright terminal panicles, male and female mingled. Fruits, globose in drooping clusters, 1.25-2.5 cm in diameter, with thin, brittle, yellow-brown to light reddish-brown rind, more or less rough (pebbled), the protuberances much less prominent than those of the lychee. The flesh (aril) is mucilaginous, whitish, translucent, somewhat musky, sweet, but not as sweet as that of the lychee and with less "bouquet".

a) b)

Figure 1.6 a) Longan tree and b) Longan fruit and leave

Reference: http://www.montosogardens.com/dimocarpus_longan.htm

Longans are much eaten fresh, out-of-hand, but some have maintained that the fruit is improved by cooking. In China, the majority are canned in syrup or dried. The canned fruits were regularly shipped from Shanghai to the United States in the past. Today, they are exported from Hong Kong and Taiwan. For drying, the fruits are first heated to shrink the flesh and facilitate peeling of the rind. Then the seeds are removed and the flesh dried over a slow fire. The dried product is black, leathery and smoky in flavor and is mainly used to prepare an infusion drunk for refreshment.

The flesh of the fruit is administered as a stomachic, febrifuge and vermifuge, and is regarded as an antidote for poison. A decoction of the dried flesh is taken as a tonic and treatment for insomnia and neurasthenic neurosis. In both North and South Vietnam, the "eye" of the longan seed is pressed against a snakebite in the belief that it will absorb the venom. Leaves and flowers are sold in Chinese herb markets but are not a part of ancient traditional medicine. The leaves contain quercetin and quercitrin. Dried flowers are exported to Malaysia for medicinal purposes. The seeds are administered to counteract heavy sweating and the pulverized kernel, which contains saponin, tannin and fat, serves as a styptic. The saponin in longan seed are used like soapberries (*Sapindus saponaria* L.) for shampooing the hair.

1.4.2 Luna nut (Lim, 2013)

Luna nut (*Lepisanthes fruticosa* , Chammaliang in Thailand) is indigenous to southeast Asia. The species is found as understorey in undisturbed to slinghtly disturbed mixed dipterocarp, keranga and sub-montane tropical forests up to 1,400 m altitude. It usually occurs along river and streams, swamp edges, moist thickets and on ridges. It grows on rich as well as poor, clayey, sandy, acid as well as basic soils. In secondary forests, it is usually present as a pre-disturbance remnant. The fruit can be eaten fresh, as it is sweet when ripe. The seed are eaten roasted. Young leaves eaten cooked as vegetables in southern Thailand.

Figure 1.7 Luna nut

Reference: http://www.infoforthai.com/forum/index.php?topic=4756.0)

The root is used in a compound poultice to relieve itching and to lower temperature during fever. Tea is made from roots can use for against rheumatism or impotence. In Thailand, Luna nut fruit is used as a remedy for flatulence and diarrhea.

1.4.3 Drumstick (Roloff, et. al., 2009)

Drumstick tree (*Moringa oleifera,* Marum in Thai) is the most widely cultivated species of the genus *Moringa*, which is the only genus in the family Moringaceae. English common names include moringa, and drumstick tree, from the appearance of the long, slender, triangular seed pods, horseradish tree, from the taste of the roots which resembles horseradish, or ben oil tree, from the oil derived from the seeds. The tree itself is rather slender, with drooping branches that grow to approximately 10m in height. In cultivation, it is often cut back annually to 1–2 meters and allowed to re-grow so the pods and leaves remain within arm's reach. In developing countries, moringa has potential to improve nutrition, boost food security, foster rural development, and support sustainable land-care. It may be used as forage for livestock, a micronutrient liquid, a natural anthelmintic and possible adjuvant.

a) b) c)

Figure 1.8 a) Drumstick tree, b) Drumstick pods and c) Drumstick flower

Reference: http://en.wikipedia.org/wiki/Moringa_oleifera

Many parts of the moringa are edible. Regional uses of the moringa as food vary widely. In some regions, the young seed pods are most commonly eaten, while in others, the leaves are the most commonly used part of the plant. The flowers are edible when cooked and are said to taste like mushrooms. The bark, sap, roots, leaves, seeds, oil, and flowers are used in traditional medicine in several countries. In Jamaica, the sap is used for a blue dye.

The leaves are the most nutritious part of the plant, being a significant source of vitamin B6, vitamin C, provitamin A as β-carotene, magnesium and protein, etc. When compared with common foods particularly high in certain nutrients per 100 g fresh weight, moringa leaves are considerable sources of these same nutrients.

The seeds, sometimes removed from more mature pods and eaten like peas or roasted like nuts, contain high levels of vitamin C and moderate amounts of B vitamins and dietary minerals. Mature seeds yield 38–40% edible oil called ben oil from its high concentration of behenic acid. The refined oil is clear and odorless, and resists rancidity. The seed cake remaining after oil extraction may be used as a fertilizer or as a flocculent to purify water. Moringa seed oil also has potential for use as a biofuel. The roots are shredded and used as a condiment in the same way as horseradish; however, they contain an alkaloid, potentially having nerve-paralyzing properties.

1.4.4 Black poum (Wattanothai payup botanical garden, n.d.)

Black poum or Jambul (*Syzygium cumini*, Waa in Thailand) is an evergreen tropical tree in the flowering plant family Myrtaceae. Jambul is native to Bangladesh, India, Nepal, Pakistan, Sri Lanka, the Philippines, and Indonesia. The name of the fruit is sometimes mistranslated as blackberry, which is a different fruit in an unrelated family.

a) b)

Figure 1.9 a) Black poum tree and b) Black poum fruit

Reference: http://www.aopdh08.doae.go.th/sara_detail3.php

A fairly fast growing species, it can reach heights of up to 30 m and can live more than 100 years. Its dense foliage provides shade and is grown just for its ornamental value. At the base of the tree, the bark is rough and dark grey, becoming lighter grey and smoother higher up. The wood is strong and is water resistant. Because of this it is used in railway sleepers and to install motors in wells. It is sometimes used to make cheap furniture and village dwellings though it is relatively hard to work on.

The leaves which are an aroma similar to turpentine, are pinkish when young, changing to a leathery, glossy dark green with a yellow midrib as they mature. The leaves are used as food for livestock, as they have good nutritional value.

Jambul trees start flowering from March to April. The flowers of jambul are fragrant and small, about 5 mm in diameter. The fruits develop by May or June and resemble large berries. The fruit is oblong, ovoid, starts green and turns pink to shining crimson black as it matures. A variant of the tree produces white coloured fruit. The fruit has a combination of sweet, mildly sour and astringent flavour and tends to colour the tongue purple.

The seed is also used in various alternative healing systems like Ayurveda (to control diabetes, for example.), Unani and Chinese medicine for digestive ailments. The leaves and bark are used for controlling blood pressure and gingivitis. Wine and vinegar are also made from the fruit. It has a high source in vitamin A and vitamin C. Jambul has been spread overseas from India by Indian emigrants and at present is common in former tropical British colonies.

1.4.5 Neem (National Research Council, 1992)

Neem tree (*Azadirachta indica*, Sadao in Thailand) is a tree in the mahogany family Meliaceae. It is one of two species in the genus Azadirachta, and is native to India, Pakistan, and Bangladesh growing in tropical and semi-tropical regions. Neem is a fast-growing tree that can reach a height of 15–20 m, rarely to 35–40 m. It is evergreen, but in severe drought it may shed most or nearly all of its leaves. The branches are wide spread. The fairly dense crown is roundish or ovular and may reach the diameter of 15–20 m in old, free-standing specimens.

a)

b)

Figure 1.10 a)Neem tree and b) Neem fruit

Reference: http://www.ehow.com/how_5006399_grow-neem-tree.html

The pinnate leaves are 20–40 cm long, with medium to dark green leaflets. The terminal leaflet is often missing. The white and fragrant flowers are arranged axillary, normally in more-or-less drooping panicles which are up to 25 cm long. The inflorescences, which branch up to the third degree, bear from 150 to 250 flowers. An individual flower is 5–6 m long and 8–11 m wide. Protandrous, bisexual flowers and male flowers exist on the same individual. Its leaf is approximately 5 to 10 cm long.

The fruit is a smooth, olive-like drupe which varies in shape from elongate oval to nearly roundish, and when ripe are 1.4–2.8 cm by 1.0–1.5 cm. The fruit skin (exocarp) is thin and the bitter-sweet pulp (mesocarp) is yellowish-white and very fibrous. The mesocarp is 0.3–0.5 cm thick. The white, hard inner shell (endocarp) of the fruit encloses one, rarely two or three, elongated seeds (kernels) having a brown seed coat.

The tender shoots and flowers of the neem tree are eaten as a vegetable in India. A souplike dish called Veppampoo Rasam (Tamil) (translated as "neem flower rasam") made of the flower of neem is prepared in Tamil Nadu. In West Bengal, young neem leaves are fried in oil with tiny pieces of eggplant (brinjal). The dish is called nim begun and is the first item during a Bengali meal that acts as an appetizer eaten with rice.

Neem is used in parts of mainland Southeast Asia, particularly in Cambodia, Laos, Thailand, Myanmar and Vietnam. Even lightly cooked, the flavour is quite bitter and the food is not enjoyed by all inhabitants of these nations, though it is believed to be good for one's health. Neem gum is a rich source of protein. In Myanmar, young neem leaves and flower buds are boiled with tamarind fruit to soften its bitterness and eaten as a vegetable. Pickled neem leaves are also eaten with tomato and fish paste sauce in Myanmar.

In India, the plant is variously known as "Sacred Tree," "Heal All," "Nature's Drugstore," "Village Pharmacy" and "Panacea for all diseases". Products made from neem trees have been used in India for over two millennia for their medicinal properties: neem products are believed to be anthelmintic, antifungal, antidiabetic, antibacterial, antiviral, contraceptive and sedative. It is considered a major component in Ayurvedic and Unani medicine and is particularly prescribed for skin disease. Neem oil is also used for healthy hair, to improve liver function, detoxify the blood, and balance blood sugar levels, and is considered to have no side effects.

Neem is a key ingredient in non-pesticidal management (NPM), providing a natural alternative to synthetic pesticides. Neem seeds are ground into a powder that is soaked overnight in water and sprayed onto the crop. To be effective, it is necessary to apply repeatedly, at least every ten days. Neem does not directly kill insects on the crop. It acts as an anti-feedant, repellent, and egg-laying deterrent, protecting the crop from damage. The insects starve and die within a few days. Neem also suppresses the hatching of pest insects from their eggs. Neem cake is often sold as a fertilizer.

1.4.6 Oak (Wikipedia : Oak, n.d.)

An oak is a tree or shrub in the genus Quercus, having 600 extant species. "Oak" may also appear in the names of species in related genera, notably Lithocarpus. The genus is native to the Northern Hemisphere, and includes deciduous and evergreen species extending from cool temperate to tropical latitudes in Asia and the Americas.

a) b)

Figure 1.11 a) Oak tree and b) Oak leaf and Oak nut

Reference: http://en.wikipedia.org/wiki/Oak

Oaks have spirally arranged leaves, with lobed margins in many species; some have serrated leaves or entire leaves with smooth margins. Many deciduous species are marcescent, not dropping dead leaves until spring. The flowers are catkins, produced in spring. The fruit is a nut called an acorn, borne in a cup-like structure known as a cupule; each acorn contains one seed (rarely two or three) and takes 6–18 months to mature, depending on species. The live oaks are distinguished for being evergreen, but are not actually a distinct group and instead are dispersed across the genus.

Oak wood has a density of about 0.75 g/cm3, great strength and hardness, and is very resistant to insect and fungal attack because of its high tannin content. It also has very appealing grain markings, particularly when quartersawn. Oak planking was common on high status Viking long-ships in the 9th and 10th centuries. The wood was hewn from green logs, by axe and wedge, to produce radial planks, similar to quarter-sawn timber. Wide, quarter-sawn boards of oak have been prized since the middle ages for use in interior paneling of prestigious buildings such as the debating chamber of the House of Commons in London, and in the construction of fine furniture. Oak wood, from *Quercus robur* and *Quercus petraea*, was used in Europe for the construction of ships, especially naval men of war, until the 19th century, and was the principal timber used in the construction of European timber-framed buildings. Today oak wood is still commonly used for furniture making and flooring, timber frame buildings, and for veneer production. Barrels in which wines, sherry, and spirits such as brandy, Scotch whisky and Bourbon whiskey are aged are made from European and American oak. The use of oak in wine can add many different dimensions to wine based on the type and style of the oak. Oak barrels, which may be charred before use, contribute to the colour, taste, and aroma of the contents, imparting a desirable oaky vanillin flavour to these drinks. The great dilemma for wine producers is to choose between French and American oakwoods. French oaks (*Q. robur*, *Q. petraea*) give the wine greater refinement and are chosen for the best wines since they increase the price compared to those aged in American oak wood. American oak contributes greater texture and resistance to ageing, but produces more violent wine bouquets. Oak wood chips are used for smoking fish, meat, cheeses and other foods.

Japanese oak is used in the making of professional drums from manufacturer Yamaha Drums. The higher density of oak gives the drum a brighter and louder tone compared to traditional drum materials such as maple and birch. In hill states of India, besides fuelwood and timber, the local people use oak wood for making agricultural implements. The leaves are used as fodder during lean period and bedding for livestock.

The bark of the cork oak is used to produce wine stoppers (corks). This species grows in the Mediterranean Sea region, with Portugal, Spain, Algeria and Morocco producing most of the world's supply. Of the North American oaks, the Northern red oak is the most prized of the red oak group for lumber, all of which is marketed as red oak regardless of the species of origin. It is not good for outdoor use due to its open capillaries. One can blow air through an end grain piece 10 inches long to make bubbles come out in a glass of water. These openings give fungus easy access when the finish deteriorates. The standard for the lumber of the white oak group – all of which is marketed as white oak – is the White Oak. White Oak is often used to make wine barrels. The wood of the deciduous Pedunculate Oak and Sessile Oak accounts for most of the European oak production, but evergreen species, such as Holm oak and Cork oak also produce valuable timber.

The bark of the White Oak is dried and used in medical preparations. Oak bark is also rich in tannin, and is used by tanners for tanning leather. Acorns are used for making flour or roasted for acorn coffee.

The leaves and acorns of the oak tree are poisonous to cattle, horses, sheep, and goats in large amounts due to the toxin tannic acid, and cause kidney damage and gastroenteritis. Additionally, once livestock have a taste for the leaves and acorns, they may seek them out. Symptoms of poisoning include lack of appetite, depression, constipation, diarrhea, blood in urine, and colic. The exception to livestock and oak toxicity is the domestic pig, which may be fed entirely on acorns in the right conditions, and has traditionally been pastured in oak woodlands (such as the Spanish dehesa and the English system of pannage) for hundreds of years. Acorns are also edible to humans in processed form, after leaching of the tannins. They are a staple part of the forage consumed by wildlife, including squirrels.

1.5 Literature Review

Tasting plays an important role in the sensory analysis of wine. Employing a trained or consumer panel, oenologists may perform a variety of tests on the taste, aroma, mouthfeel and appeal of wines. Difference tests are important in determining whether different fermentation conditions or new vineyard treatments alter the character of a wine, something particularly important to producers who aim for consistency. Preference testing establishes consumer preference, while descriptive analysis determines the most prominent traits of the wine, some of which grace back labels. Blind tasting and other laboratory controls help mitigate bias and assure statistically significant results. Many large wine companies now boast their own sensory team, optimally consisting of a Ph.D. sensory scientist, a flavor chemist and a trained panel.

Garde and Ancin (2006) reviewed about quality factors on wine aging in oak barrels. Extraction of volatile compound from oak barrels depends mainly on the quantity of compounds that are potentially extractable, the contact time between wine and oak wood and the wine composition. However, compounds extracted by wine from barrels undergo transformations, mainly microbiological ones, which modify the concentration of these substances in wine over time. In addition, wine compounds can be sorbed by wood and by wine lees, so that this factor can also have an influence on wine volatile composition. A significant problem is that in wines aged mainly in barrels which have been reused, ethylphenol could be formed and these are undesirable compounds for wine quality since they confer unpleasant odours to wine.

When it comes to deciding about the length of time for wine aging in barrels it is necessary to take into account several factors such as wine composition and characteristics of barrels. Adapting wood to wine is not an easy matter. Aging duration is highly variable depending on a wine's origin, type and quality. The aim of this study is to investigate the behavior of new barrel and once-used barrels depending on the aging period of wine. From the results obtained it can be seen that for aging wine during a short period (6-9 months), there was quite a big difference in the concentration of most of the oak wood compounds between wine aged in new barrels and in once-used barrels. However, due to the chemical or biochemical transformations of certain compounds from oak wood in wine over time, their concentrations in long-term aging (12-15 months) were similar of both wine aged in new barrels and in once-used barrels. The compounds which became more exhausted from aged barrel, furanic aldehydes, phenolic alcohol, phenolic aldehydes and oak-lactone.

Although, main quality of wine was specified by sensory taste, but the chemical composition in wine is important too. Flavor and aroma compounds in wine were generated during fermentation and aging step. Grape or fruit carried a lot of ester compounds, and some of ester compound may be generated in fermentation step by chemical reaction of yeast and chemical substance in wine. Aging step is important because during aging, chemical substances in wine (alcohol, acid and other) were reacted with its self and oak wood.

Vanillin, guaiacol, syringaldehyde, gallic acid, oak lactone and others (for example,flavanoid and flavone) substance were generated with chemical reaction of wine with wood.

Chemical composition analysis in wine can be analyzed by several technique, gas chromatography mass-spectroscopy (GCMS) or high performance liquid chromatography (HPLC) and liquid chromatography mass-spectroscopy (LCMS) (Teresa, 2007).

Teresa (2007) were reported the result of wine quality compare between barrel and oak chips, and identified the pheonolic compounds by HPLC technique, column C-18 was used as separated column. The eluent was 0.8 mL/min by gradient elution (water to methanol with 2% formic acid), and all of chemical compounds were detected at 280 nm and were identified by comparing their retention times with those of several standards. The result show that, there are a lot of phenolic compound in old barrel (used barrel) more than new barrel and oak chip respectively.

A headspace solid-phase micro extraction (HS-SPME) and gas chromatography (GC) coupled to mass spectrometry (MS) method were developed to identify and quantify 14 volatile oak compounds in aged red wines (Teresa, 2007). The most important HS-SPME variables were optimized by experimental design technique in order to improv the extraction process. The selected conditions was: 10 mL of sample in 20 mL sealed vials with addition of 30% of sodium chloride (saturated solution), divinylbenzene-carboxen-polydimethylsiloxane (DVB-CAR-PDMS) fibre, 10 min of pre-incubation time, 70 ° C of temperature and 60 min of extraction time without agitation. The features of the method were established for the studied compounds in terms of linear range, slope and intercept of the calibration graphs, detection and quantification limits and repeatability. For all compounds detection limits were below their threshold levels and repeatability, in terms of relative standard deviation, was good, with values between 3 and 11%. Finally, the method was applied to the analysis of six aged red wines by both internal standard and standard addition calibration methods. The concentrations obtained with both methods were statistically compared.

Camara (2006) reported the influence or the age in the volatile composition of Madeira wine made with Boal, Malvazia, Sercial and Vendelho varieties and aged in oak barrel during 1, 11 and 25 years old. The result show that during aging, the concentration of fatty acid ethyl ester, acetate and fatty acids decreased significantly, but some of volatile compound, for example, fufural or lactone increased. Furfural derived from sugars are also involve the aroma of white wine. The sensory properties change significantly after long periods of conservation.