

How Wine is Made, Course #17  
Fall, 2009

LECTURE 1

Biology – Plant and Microbial: grapevine biology including genetics; yeast; pests and pathogens; beneficial soil microbes in the vineyard, understand spoilage microorganisms for better control

Chemistry – chemicals in wine are derived from chemicals in grapes = natural products chemistry; clarify wine (adsorb to eliminate cloudiness); aging process; predictable stability in the bottle (color, tannins, acidity)

Physics – temperature during production and storage; what the wine is made in due to surface-volume ratio impacting temperature dissipation during fermentation

Engineering – application of biology, chemistry and physics to the design and operation of wineries; predictability through process control; computer process control, wastes, waste gases

Medicine – impact of wine consumption on people; alcoholism; fetal alcohol syndrome; health benefits

Sociology – alcohol abuse on society costs due to accidents, work loss, families; rural societal traditions particularly Europe; migrant labor issues and people coming in from other countries;  
Prevailing religion where people live and what they practice

Geography – Physical - delimiting appellations, climates and soils; cultural – wine is a part of the local culture and interaction with food; often the type of wine made is related to the food in a location

Economics – highly significant in many parts of the world; a very big business including wine itself and trickle down impact; international trade import-export

Law – subject to regulation because it is an alcoholic beverage; ATF and State; international law; labor law

History – the history of wine is the history of Europe

Humanities – literature, art, music, European languages

Worldwide wine production – France biggest producers in volume, followed by Italy; Spain has more vineyard area than any other country but not as productive;

US is fourth (the most of any country outside Europe); 90% of all wine sold in US comes from CA, not considering imports; 74% of all wine sold including imports comes from CA

Wine - fermentation of grapes by yeast

Viticulture - study of grape cultivation

Enology - study of wine and winemaking

Different types of wine – Classification Schemes:

Color (red, white, pink [rose, blush]);

Grape Varietal names; Cabernet Sauvignon – red grape of Bordeaux; Pinot noir – red grape of Burgundy; Zinfandel – red grape originally from Croatia; Chardonnay - white grape of Burgundy; Sauvignon blanc – white grape of Bordeaux, along with Semillon

Generic wine e.g., red table wine; Semi-generic e.g., California Chablis

Place of origin where grapes are grown;

Price – least expensive is “jug” under \$3 per bottle, most expensive is “luxury premium” over \$25; popular premium “fighting varieties” is very competitive and includes many new world wines;

Sweetness; dry wine is that which does not taste sweet (below detection level of sweetness);

Effervescence – sparkling, carbonated, still (no perceptible fizziness);

Alcohol concentration – table wine <14% by vol, desert wine >14% by vol

In traditional European wines, geographical place names are most common; New World uses varietal name designations

Regulated – varietal and geographic minimum percentages

In US Table wine is <14%; in Europe it is the lowest quality (ordinary) category for wines that does not qualify for a higher category

## LECTURE 2

Flavor comes from grapes, fermentation, process & aging. The most important factor in wine flavor

Fundamental, distinct wine flavor comes from genetic variety of grape, impacted by where (environmental and geographic conditions) and how grapes are grown (training, watering, pruning)

Grapes are an ideal fruit as they accumulate a tremendous amount of sugar, which is the base material the yeast uses to make alcohol; stability in the bottle is dependent upon sufficient alcohol and acid levels

Yeast needs nitrogen to grow and multiply, along with vitamins

Yeast is on the outside, waxy covering of the grape berry

Today's grapes are derived from wild plant relatives, woody vines with tendrils and berries related to Boston Ivy, Virginia Creeper, Grape Ivy

*Vitis vinifera* (European wine grape) with over 5,000 varieties, native to the Mediterranean (mostly temperate regions) as a wild plant; helps to define successful climatic conditions warm dry summers, not too cold winters which are supportive; in Northern California there is *vitis californica* that likes stream beds having great instructional value. *Vitis vinifera* is not native to US

All grapevines lose their leaves in the winter

In general, the coastal regions are best; In US the North is too cold in winter; the South has Pierce's disease; areas around bodies of water provide protection from winter cold (Finger Lakes in NY, Pacific Ocean in WA are Concord-type grapes *vitis labrusca* which also grow wild in North America)

Pierces Disease bacterium on sucking insects mouth parts and spread from vine to vine; they kill the vine, *vitis vinifera* will not last much more than 2 years; in CA the disease is widespread throughout the state but is a patchy 'hotspot' phenomenon

Cabernet Sauvignon – red grape of Bordeaux; the most important red wine grape variety; almost black berries beneath the waxy coating; small clusters with loose berries

Pinot noir – red grape of Burgundy

Zinfandel – red grape originally from Croatia

Chardonnay - white grape of Burgundy

Sauvignon blanc – white grape of Bordeaux, along with Semillon

Thompson Seedless are *Vitis vinifera*, common table grapes, most all the world's raisins

Wild grapes of North America that are commercially important - *Vitis labrusca* (Concord) grape juice is colored, *Vitis vinifera* always has clear juice; *Muscadinia rotundifolia* grows wild in the Southeast US with no clusters and has a unique flavor; *Vitis riparia* and *Vitis rupestris* used for rootstock, they are naturally resistant to phylloxera (killed half of the vineyards in France when native NA plants were brought over)

Hybrid Direct Producers - Europeans cross pollinated resistant NA root stock with European *Vitis vinifera* resulting in a blended plant

Grafting – Grafted dormant European scion (e.g., Cabernet) *Vitis vinifera* to dormant NA rootstock (e.g., *Vitis riparia*) results in a compound plant

Powdery mildew is most common fungus, a type of microbe; weakens the vine and makes fruit unusable, but does not kill vine; controlled by elemental sulfur (not a pesticide and does not invalidate organic designation)

Botrytis bunch rot can destroy the fruit cluster; Botrytis “Noble Rot” can enhance the fruit sweet/honey if lightly coated (e.g., sauterne wine)

Leafroll – virus diseases are European and Asian which restrict productivity but tend not to kill plant; deep red color in the Fall; use clean planting stock when planting

Pierce's Disease – Fatal; glassy wing sharpshooter feeds on woody part of vine and spreads systemically, blue green sharpshooter feeds on shoots which are pruned in winter and is not as serious a problem

### Lecture 3

Vine Cycle - In California the vine cycle begins around April 1, when new shoots emerge from the dormant bud. Shoots elongate during April and May and the vine flowers around May 15. Tiny berries begin to grow but remain green and hard until about July 15.

Veraison - The onset of ripening, begins then and the berries begin to develop color and to soften. Fruit is usually harvested around September 15, but this date

varies with the variety, the location, and the weather. In November or December, the vine loses its leaves and enters dormancy. Pruning usually takes place between December and February.

**Dormant Buds** - Because these buds contain the developing flower clusters that will produce the next year's fruit, the environmental conditions that exist this year and the farming practices used this year will greatly influence next year's crop. The dormant bud begins to develop near the end of the summer.

**Berry Structure** - The pigment in grape berries that produces the color of red wine is found in the skin of the berry. The tannins in the seeds (and skins) contribute bitterness and astringency to the flavor of the wine.

**Berry Composition** - Between veraison and harvest, the composition of the berry changes markedly. The sugar concentration rises from about 4% to 20–28% as sugar is transported into the fruit from the leaves.

In the U.S. the °Brix scale is used, equivalent to % sugar by weight. Ripeness or maturity is a matter of taste, but grapes for wine production are usually harvested between 19 and 24°Brix (compared to 16 to 18°Brix for table grapes).

Between veraison and harvest, the acid concentration (largely malic and tartaric acids) decreases from around 3% to less than 1%. Most of this decrease is due to dilution because the berry is increasing in size and water content. Some of the malic acid is also lost by respiration (the conversion of malic acid to CO<sub>2</sub>). During this time, pigments develop in the skin of red varieties, flavor compounds develop and the tannins in the seeds also increase.

**Harvest** - The decision to harvest wine grapes is typically made on the basis of sugar and acid concentrations. The sugar must be high enough to produce the desired alcohol concentration in the wine and the acid must be high enough to maintain the desired tartness.

However, winemakers are also interested in varietal character. Key flavor compounds may not always reach their optimum concentrations at the same time as the sugar and acid, so the winemaker must carefully monitor the development of the fruit as it nears maturity, often by tasting the fruit in the vineyard.

**Temperature** - Environmental conditions greatly affect the grapevine and its fruit. The date at which the vine leafs out in the spring is determined by temperature, as is the rate at which the vine progresses through its growing season. Varieties differ in the amount of heat they require to mature their fruit.

**Hotter Areas** - In hotter areas, grapes can reach very high sugar concentrations but the acidity is lower because of increased loss of malic acid by respiration. Color and flavor intensity are also usually lower in fruit produced in hot regions.

The amount of fruit produced is higher. Extreme heat, however, can result in shriveled fruit and arrested sugar accumulation. Grapes for premium wine are not usually grown in very hot locations because they will lack distinctive varietal flavors. Hot areas are ideal for the production of dessert wines, however, because high sugar is desirable in order to achieve the high alcohol concentrations of these wines and varietal distinctiveness is not as important.

Cooler Areas - In cooler regions, sugar accumulation is slower and yield is lower. In very cool areas, the grapes may not even reach maturity. Acidity is generally higher in cool areas because respiration is reduced. Color and flavor intensity are increased and maximum varietal distinctiveness is achieved in cool areas.

The vineyards from which California's premium wines are produced are in relatively cool areas, notably the coastal valleys. Wine grapes produced in these areas are typically 10 times as valuable as those produced in the hottest areas of California, but this differential is partially offset by the 2 to 3-fold higher yields obtained in the hotter areas.

Although a location may have adequate heat accumulation through the spring and summer, the winters may be cold enough to kill the above-ground parts of the vine. This kind of low temperature damage is called winter kill.

A different kind of low temperature risk is spring frost, which destroys the new shoots of vines when warm spring weather is followed by below freezing temperatures. Because the crop loss can be so severe, grape growers in coastal valleys that are subject to spring frosts typically have frost protection equipment, such as smudge pots that warm the air around the vines, wind machines that mix cold air with warmer air above and sprinklers that cause ice to form on the shoots and prevent the temperature from dropping further.

Cool temperatures occurring around the time of flowering can interfere with flowering and consequently reduce the number of berries that form.

Water - Winter rainfall is ideal for grapevines because their deep roots can extract stored moisture from the soil throughout the growing season. Rain at the time of flowering interferes with fruit set and summer rain encourages bunch rot and other fungal diseases. Rain at harvest can also result in swollen berries and reduced sugar. Places that have wet winters and dry summers, like California, are well suited to viticulture.

Most traditional vineyards in Europe are not irrigated, but irrigation is common in California and the rest of the New World.

Soil - Soil supports the vine and is a reservoir for nutrients and water. Many of the differences in wine flavor that are attributed to soil are due to the different water holding capacities of various soil types.

Propagation - Grapevine plants are usually purchased from commercial nurseries as grafted plants. The scion variety has already been grafted to the rootstock in the nursery. New vines do not produce much fruit until the third or fourth year after planting.

A vineyard in California typically has a life of about 20 years, after which time the vines are removed because they are diseased or because the grower wishes to plant a different variety or to use a different spacing or trellising system.

Vine Management - A grape grower can exercise considerable control over fruit composition and thus wine flavor by managing the way a grapevine grows. The size and shape of a grapevine are controlled by training, trellising, and pruning. Many training and trellising styles have evolved throughout the world.

Vines in California were once typically head trained and free-standing (e.g., old Zinfandel vines) but now most are trained on wires, often as bilateral cordons. With trellised vines, one wire typically supports the permanent arms of the vine and additional wires above support the foliage so that it can receive adequate light exposure.

Pruning - Pruning is one of the most important tools for controlling a grapevine. It not only controls the size of the vine but, because it establishes the number of dormant buds the vine will have, it also determines the total number of clusters and thus the total amount of fruit the vine can produce the following year.

A vine left with too few buds may be excessively vigorous with a resulting reduction in fruit quality. Conversely, a vine left with too many buds will be overcropped—it will not be able to produce enough sugar to fully ripen its fruit clusters. The ratio of fruit to foliage and the amount of light that reaches both leaves and fruit are critical to the development of high quality wine grapes.

Canopy Management - The total foliage of the grapevine is called the canopy. Good grape growers know that the way they manage the canopy affects the flavor of the resulting wine. They aim to balance the amount of fruit and foliage, to avoid both overcropping and excess vigor. They also try to maximize the amount of light that reaches all the leaves.

In addition to pruning during the winter, they may also trim the vines during the summer (summer pruning) and remove leaves in the vicinity of the fruit clusters.

## LECTURE 4

Must – crushed grapes and juice to be fermented

Pomace – skins and seeds left after pressing

Yeast, single cell fungus; *saccharomyces cerevisiae* (the fungus which feeds on sugar) also found on the surface of grape berries, but in much lower numbers than wild yeast; outcompetes wild yeast; alcohol tolerant, SO<sub>2</sub> tolerant; predictable, vigorous, ferments to dryness, high temperature tolerant, minimal off flavors

Feral yeast – commercial yeast that has been introduced into the vineyard (pomace) and on winery equipment

Wild yeast - off flavors, alcohol intolerant, SO<sub>2</sub> sensitive -> unpredictable and microbiologically unstable, can result in wine that is cloudy & fizzy in the bottle

Natural fermentation – a fermentation that is not inoculated, fruit comes in on the fruit or is floating around the winery; may take longer for the fermentation to start, off flavors, stuck fermentation, etc.

Flavor differences are not significant except in very young wines; exception is sparkling wines

Yeast needs nutrients in its food source: sugar (carbon source) -> glucose and fructose in the grape juice; can break down sucrose if used; nitrogen for amino acids -> DAP supplement if necessary; vitamins (biotin); minerals; low pH between 3-4; temperature range 50-100°F (fastest at 80-85°F); ethanol below 16%

Wine yeast reproduce by budding

Respiration: glucose plus oxygen yields carbon dioxide, water; 680 kcal energy per mole of glucose, but requires oxygen

Fermentation: glucose yields ethanol and carbon dioxide; 56 kcal energy per mole of glucose, does not require oxygen; ethanol is a byproduct and is toxic to yeast

Heat - Some energy is stored as ATP; most energy (34 kcal) is lost as heat; 1\*Brix drop -> 2.3°F rise

Alcohol – 55% by volume; start with 20\*Brix will result in wine of 11% (using .55 conversion ratio)

Fermentation can take a few days to a few weeks depending upon temperature; red wines ferment more quickly, they are at a higher temperature because they are a richer source of nutrients for yeast (skins and seeds); Microbiological stability – no unintended microbiological actions in bottle

Stuck fermentation – stops before sugar is used up which is caused by depletion of N or P and/or overheating; more common with white wines because they are more likely to be nutrient deficient

Malolactic bacteria ferment malic acid resulting in a malolactic fermentation (MLF) which reduces the acidity of the wine by converting malic acid to lactic acid; generation of CO<sub>2</sub>, produces diacetyl resulting in a buttery flavor; inhibit ML bacteria by SO<sub>2</sub> or use of a sterile filter; almost all red wines go through ML fermentation, as well as high end Chardonnays

Acetobacter – the vinegar bacteria; requires oxygen; control by excluding air; inhibited above 14% alcohol; SO<sub>2</sub> sensitive; wine left open on the counter will turn to vinegar

Brettanomyces – wild yeast; horsey smell; more sensitive to SO<sub>2</sub> than wine yeast; common in organic wines (because no added SO<sub>2</sub>)

## LECTURE 5

Sugar Measurement - Take a 100 berry sample throughout the vineyard; measure sugar concentration; measurement technique is based on solutions having different levels of solutes; refractometer – sugar in berry bending light, hydrometer – solutions that are more or less dense; can also use hydrometer during fermentation process

Acid Measurement - color indication when adding drops of agent – change when the acidity is neutral

Flavor Determination – no instrument to measure, depends upon an experienced human palate; flavor is a tradeoff with sugar and acid

Can estimate alcohol concentration in wine;  $.55 \times \text{*Brix}$ ; Alcohol considerations - gives mouth feel to wine; low alcohol wine (9%) will taste tart and thin; >14% creates a burning sensation (hot); also higher taxes

Veraison - onset of ripening (sugar development), color change, softening

Acid - Fixed amount of acid in berry from the beginning, will be respired away and percent per volume will be reduced as berry expands with liquid, wine will taste flat if acid is too low

Typical sugar concentration at harvest time – red wines have highest sugar, less for whites, grapes for sparkling wines will have much lower concentration (first picked) because the process involves 2 fermentations and alcohol can get too high

Crushing – Crusher/Stemmer, the stems are carried out the end by a screw conveyor, rollers crush the berries resulting in must (juice, skins, seeds)

Whole cluster – white wines can go direct to press to minimize influence of skins and seeds, carbonic maceration (ie. Beaujolais nouveau) for red grapes

SO<sub>2</sub> addition – a normal part of antimicrobial (wild yeast, other) and antioxidant (air/oxygen that causes browning for white wine) processing

Sulfite labeling – if >10 ppm SO<sub>2</sub> which includes almost all California wines

Organic wine – no added SO<sub>2</sub>

Low sugar – cool regions; needed to harvest before rain; chaptalization - artificially increase sugar by adding sugar to the must (illegal in California) or adding grape juice concentrate to enrich sugar level

Warm regions – lower acid, sometimes acid needs to be added to must for balance, tartaric acid is most common

Pressing – squeeze to separate liquid from solids (crushing opens the berries); pressing done before fermentation for white and blush wines, after fermentation for red wines

Press Fractions – Free run (gravity only) highest quality/lowest tannin (less bitter, less astringent), the more pressed the greater the tannin, hard press – very tannic

Juice volume – approximately 140-190 gallons/ton; more juice from red must because berries are softer after fermentation, white juice is less because of lighter press and done before fermentation

Presses – basket press (vertical), membrane/bladder press (horizontal cylinder); press program uses an on/off sequence, membrane press gives very high quality without significant difference in press fractions.

Settling – solids still exist after pressing and sink to bottom of tank (lees), pump out from top or filtering/centrifugation, racking, grape solids -> juice lees, after fermentation -> yeast lees

## LECTURE 6

Fermentation – yeast added (inoculated) with dry yeast at 1-2 percent by volume, natural fermentation does not have any added yeast

Fermentation vessels - Temperature controlled (jacketed) stainless steel fermentation tanks are most common, usually closed for white wine to prevent air and acetobactor contact, reds more often left totally open or have a lid

Heat from Fermentation - yeast converts glucose to ethanol, carbon dioxide and energy released mostly as heat, 2.3°F increase for each 1°Brix drop, yeast dies at 100°F

Example: 22°B juice at 70°F,  $22 \times 2.3 = 50.6^\circ\text{F}$ ,  $50.6^\circ\text{F} + 70^\circ\text{F (ambient)} = 120.6^\circ\text{F}$

White wines are fermented at lower temperatures for flavor

Temperature control – Jacketed SS tanks, heat exchangers used to heat and cool tanks

Fermentation lock – a one way valve which lets CO<sub>2</sub> out but prevents entrance of air

A problem fermentation is one that does not go to completion

Wine can be microbiologically unstable in the bottle which can result in wine being cloudy (from ML bacteria) and/or fizzy (from CO<sub>2</sub>). Can use sterile filtration to remove microbes

Stuck fermentation – if due to nutrient deficiency (N and P), can add DAP to restart fermentation, if due to overtemperature, will need to add fresh yeast

ML Fermentation – Malic Acid → lactic acid + CO<sub>2</sub>, beneficial for wines that are high in acid

Barrel Aging – used after fermentation to take on specific characteristics (vanilla, spicy, smokey from toasted barrels); need relatively high humidity in barrel cellar to reduce loss of liquid from evaporation, typically temperature and humidity controlled, often need to add wine every few weeks – months to top off barrels when liquid is lost due to evaporation

Racking – traditional method to separate juice from settled solids/lees (yeast, berry pulp); may add SO<sub>2</sub> to prevent growth of microbes and oxidation

Fining – used to improve clarity and reduce tannins, bentonite is a typical agent for clarity, egg whites and caessin for tannins

## LECTURE 7

Tartrate Stabilization – Lots of tartaric acid, crystals can form (precipitate out) when wine is chilled, potassium acid tartrate (KHT), consumers maybe concerned thinking it is broken glass in white wine. Control by letting it happen in the winery first, not after bottling. Chill for several weeks – cold stabilization. Can also control through ion exchange to replace potassium ions with sodium or hydrogen.

Ion Exchange - Done in large wineries because faster and cheaper. Downside, make increase sodium or acidity (not necessarily bad for California wine).

Filtration – Course filter using diatomaceous earth to remove particulate matter; sterile filter with very small pore size for microbiologicals, particularly important for wines with residual sugar/stuck fermentation or intentionally sweet, or wines not going through ML (malalactic acid ->malalactic bacteria->ML fermentation. Do not need to filter if no residual sugar, ML taken place, clear due to racking. Small wineries - unfiltered wine may be a positive selling point due to added complexity.

Blending – An art. The ultimate winemaking decision. Combine wine from different origins. Done first on small scale tests (e.g., mixture of barrel fermented and tank fermented Chardonnay to determine best proportions/blend components). Because done from barrels before wine is finished, often cloudy at this point.

Bottling – Transferred to holding tank and SO<sub>2</sub> is added. Bottles washed with hot water and sparged with nitrogen so headspace will be mostly nitrogen, not air. Corks come mostly from cork oaks in Portugal and Spain. Harvest every 10 years and corks are punched out. Concern from bad corks due to fungus interaction when bleached, tricholoroanisole (TCA) provides a wet paper odor/corked. Happens about 1% and is an individual bottle problem. Has generated interest in synthetic closures and alternatives (screwcaps).

Must keep bottling area clean to keep microbe-free particularly for wines not totally dry or ML'd. Bottles maybe kept in the winery undergo some additional aging often in a humid cellar. Red maybe held couple of years; whites immediately. Check for stability periodically before release. Need to wear safety glasses in the event that bottle breaks.

## Color and Tannin

Red wines - protection from air is not so important for red wines because color change from oxidation not an issue and because has natural antioxidants, lots of CO<sub>2</sub> generated due to vigorous fermentation- a blanket under the cap forms and protects from oxidation; need to have adequate color extracted from skins and tannin extraction primarily from seeds. More rapid extraction from higher temperature and alcohol formation (solvent effect). Extended maceration 10-30 days after fermentation is completed (typically 4-12 days). Will not get more color from EM, which peaks after just a few days, but tannin concentration will continue to increase.

Cap Management - Mixing of skins and seeds which float on surface of wine, with CO<sub>2</sub> underneath. Need to mix back in to for tannin extraction and because the cap will spoil upon drying. Punching down or pump over from bottom to top of tank. Typically done 2 times per day. Alternately, use a continuous rotary fermentor (like a concrete truck).

Carbonic Maceration – Red wine method. Done with whole clusters of fruit. Place in a bin, cover with SO<sub>2</sub>. Softening takes place within the berries. When they break open, a normal fermentation is initiated. Typically a Beaujolais Nouveau (Gamay noir grape), having a bubble gum flavor.

White Wine - need to minimize color from skins and tannins from seeds. If keep wine cool, will minimize reactions and press immediately. For high end Chardonnay, typically some barrel fermentation. Barrel fermentations do not generate much heat. Sur lies aging – keep wine in contact with dead yeast in barrel to develop flavor (Chardonnay or Champagne).

Blush Wines - made in the same way but grapes are different. Tank ferment (not barrel ferment) to avoid wood flavors.

Sweet White Wines - can either arrest fermentation by chilling or sterile filtering, or adding a sterile juice concentrate after fermenting to dryness.

## LECTURE 8

CO<sub>2</sub> is dissolved/in solution and under pressure. Remains in solution and escapes when bottle is opened

Legal Definition (Taxes!) = more than .392g CO<sub>2</sub> per 100 ml or 1atm; usually 5 atm

More sensation to sparkling wine, people enjoy it; appearance and aroma compounds are distinctive

CO<sub>2</sub> comes from a second fermentation in a closed container (crown capped bottle) where gas cannot escape

To call it sparkling wine, CO<sub>2</sub> must be developed through fermentation; if CO<sub>2</sub> added, it is carbonated wine

The higher the pressure, the lower the temperature, the higher the alcohol -> the more CO<sub>2</sub> can be dissolved in wine

Champagne was probably a result of a stuck fermentation that resumed in the spring after bottling. Discovered, not invented in multiple places such as France, England, Italy simultaneously. Legend (Monk Dom Perignon in 1600's – "I am drinking stars")

Start with low sugar grapes (18-20\*B). Harvested earlier than for other types primarily because there is a second fermentation so that there is not too much which would inhibit fermentation/kill yeast and/or have too much alcohol.

Classic varieties which emulate wines of France – Chardonnay, Pinot noir, Meunier from coastal regions. For less expensive wines use French Colombard, Chenin blanc from Central Valley

No crushing/destemming – go direct to press to have the minimum contribution from skins and seeds. Red grapes are often used for best

Usually blended using several varieties such as the 3 classic varieties. Exceptions – Blanc de blancs from Chardonnay only; Blanc de noirs from Pinot noir only which is a black grape

Base wine called cuvee – a dry, low alcohol wine (9-11%) and high acid (0.7 – 0.9 g/100ml) because harvested at low sugar (not fully mature); low SO<sub>2</sub> concentration because more yeast will be added for second fermentation which could inhibit yeast activity

Three methods – Methode champenoise (traditional) which is labor intensive and produces the best wine all happens in the bottle; Transfer, Charmat process (bulk)

The Tirage = syrup added to base wine which contains yeast, sugar, wine

Key Calculation: Sugar = 4 g/l -> 1 atm; want 6 atm in standard wine; add 6 x 4 = 24 g/l sugar = 2.4\*Brix 2.4\*B x 0.55 = 1.3% alcohol increase

Fermentation – typically 1 to 3 months

Aging - 1-5 years to get yeast flavors (aging on lees - the sediment accumulate on the side of the bottle)

Riddling – drive sediment into neck by gradual rotation and tipping over a few weeks by hand; can be done by machine over a few days

Disgorgement – plug of dead yeast is removed; neck is frozen brine solution having very low freezing point, the residual pressure forces out the plug without losing much CO<sub>2</sub>

Dosage – add some additional sugar because the wine is very acid to bring to desired level of sweetness

Cork, add wire cage, and label

Transfer process - not used very much – avoids riddling – bottle emptied into pressurized container and re-bottled

Charmat process (bulk) – second fermentation done in tank and bottled at the end, has no yeast flavor and is very uniform

