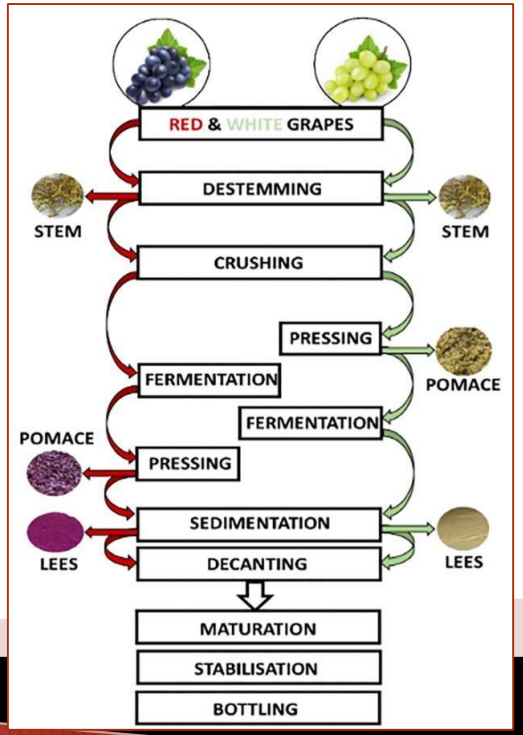
FDE 437
FERMENTATION TECHNOLOGY

Wine Production-Part II



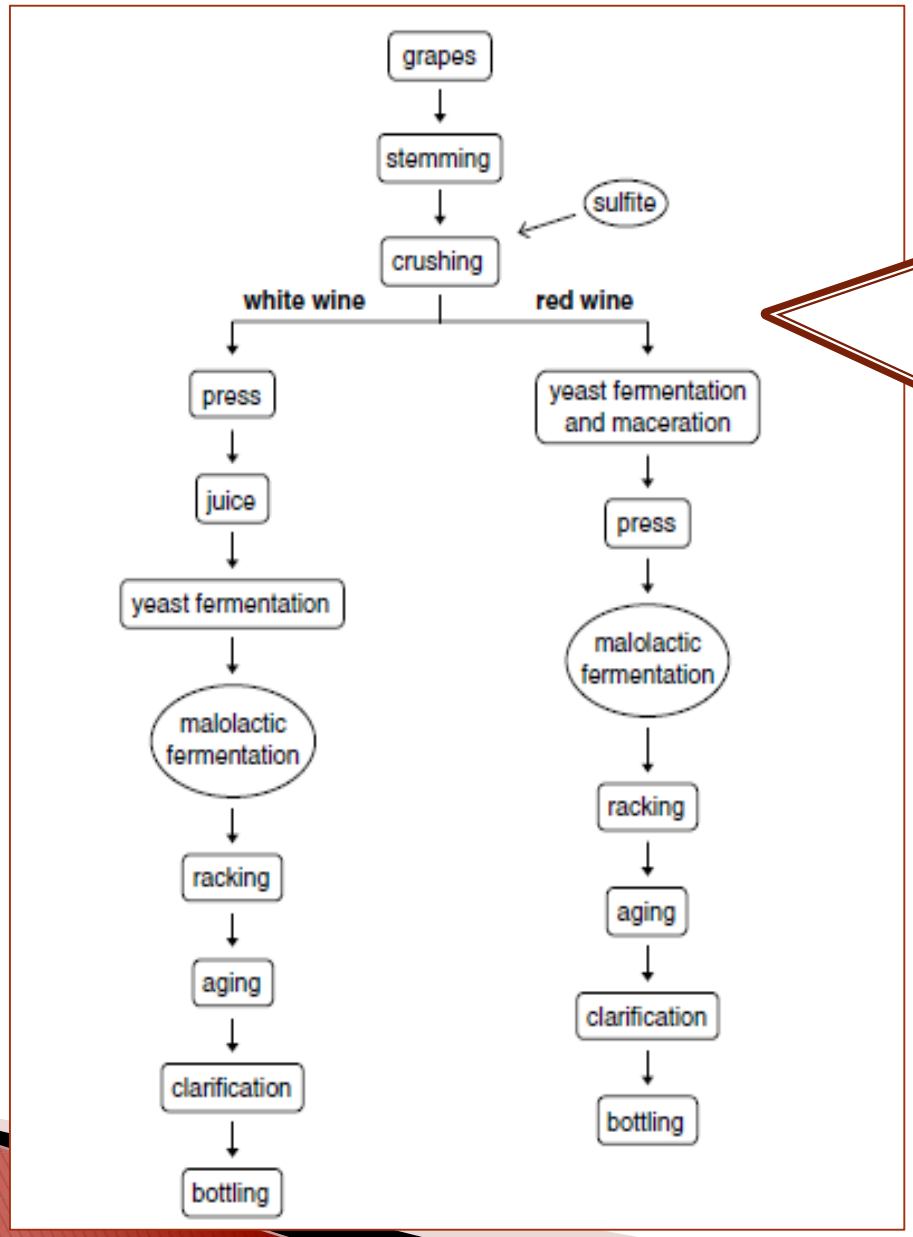
Wine Manufacture Principles

- Making wine, as far as the actual steps are concerned, appears to be a rather simple and straightforward process.

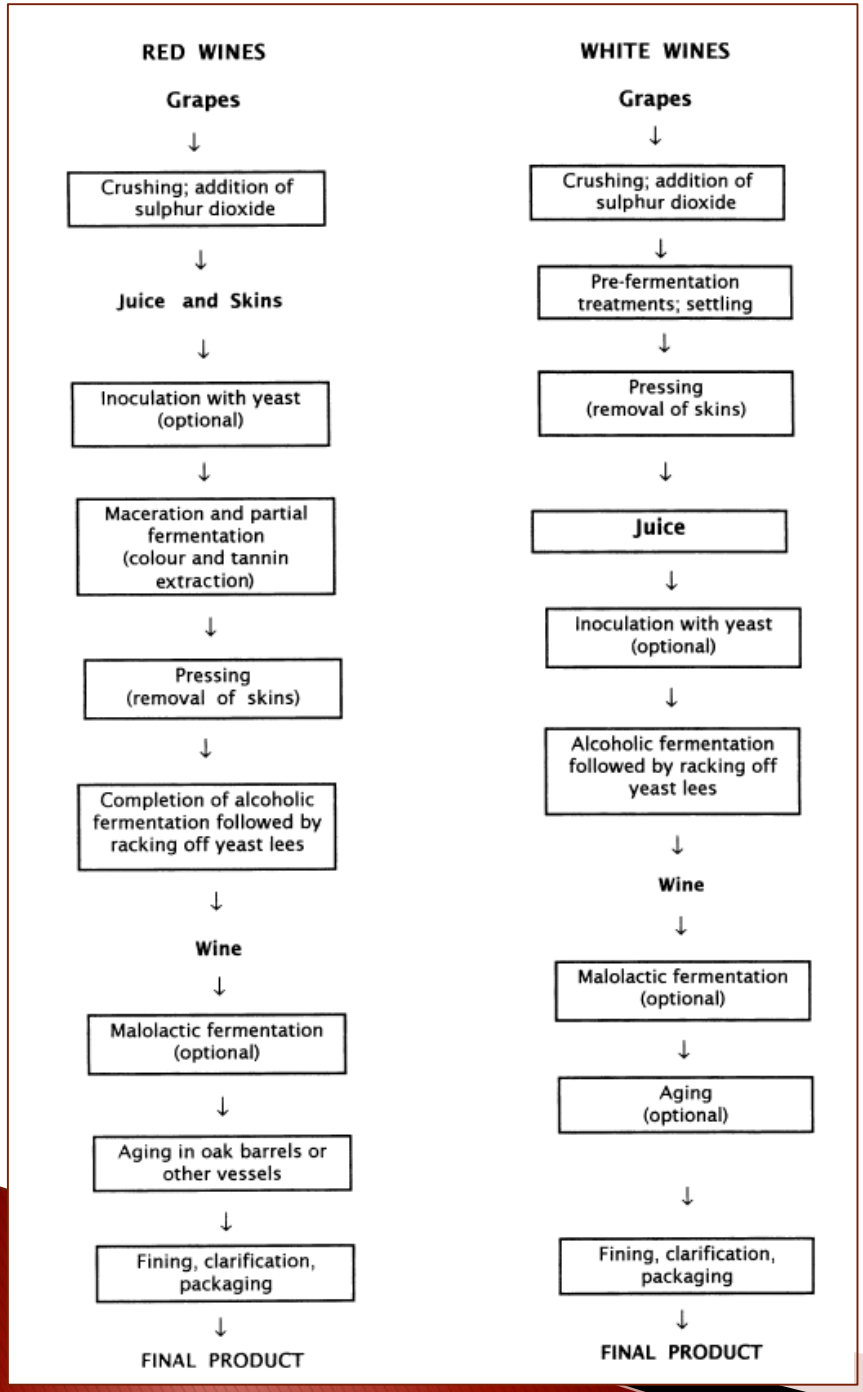
- **Grapes are harvested and crushed, the crushed material (i.e., juice or must) is fermented by yeasts and bacteria, the organisms and insoluble materials are removed, and the wine is aged and bottled.**

- In reality, the process is far from easy, and each of these pre-fermentation, fermentation, and post-fermentation steps must be carefully executed if high-quality wine is to be consistently produced.

Flow Chart of Wine Manufacture



- **The main difference between the manufacture of red and white wine** is that the grapes for red wines are fermented in the presence of skins and seeds (**maceration**), whereas for white wines, these materials are removed after crushing.



Outline of processes for red wine and white wine production

Essentially, the winemaking process consists of;

- crushing the grapes to extract the juice,
- alcoholic fermentation,
- malolactic fermentation if desired,
- bulk storage and maturation of the wine in the cellar,
- clarification,
- packaging and sale.

Harvesting and preparing grapes for wine making

- **Harvesting or picking** is certainly **the first step** in the wine making process.
- According to both viticulturists and enologists, the first step in wine making, harvesting the grapes, is considered to be one of the most important.
- Grapes must be picked at just the right level of maturity. This means that **the concentrations of sugars and acids (and the sugar/acid ratio)**, **pH**, **the total soluble solids**, and **the phenolic constituents** must be at just the right level for the particular cultivar and the type or style of wine being made.
- In addition, **berry size and weight** also influence the time at which grapes are harvested.
- In general, grapes should be sampled sometime before their expected harvest time and their composition assessed (at minimum, the °Brix and pH should be measured) to make sure that over-ripening does not occur.

Harvesting and preparing grapes for wine making

- Unfortunately, there is no exact or objective set of rules to ensure or predict the optimum time for harvesting grapes. Rather, grapes are frequently harvested based on more subjective criteria, such as color, firmness, and taste (as well as the collective wisdom and experience of the winemaker).

- As grapes ripen on the vine, **the sugar concentration**, as well as **flavor and color components** ↑, and **acids** usually ↓, so identifying the correct moment for harvesting can be a real challenge.

- It is possible for grapes to over-ripen, such that the harvested grapes contain too much sugar or too little acid or be too heavily contaminated with wild yeast and molds.

- Once the grapes have been deemed properly mature, it is essential that they be picked and harvested quickly, since the composition can continue to change.

Crushing and maceration

Crushing:

- The purpose of crushing is **to extract the juice from the grapes**.
- Before the grapes are crushed, leaves, large stems, and stalks are removed. (Selected ripe grapes are crushed to release the juice which is known as 'must', after the stalks which support the fruits have been removed. These stalks contain tannins which would give the wine a harsh taste if left in the must.)
- After destemming (once the extraneous material is separated and removed), the grapes are crushed by one of several types of devices.
- **Roller crushers** consist of a pair of stainless steel cylinder-shaped rollers.
- Another type of crusher, called the Garolla crusher, not only performs the crushing step, but also removes stems.
  - It consists of a rotating shaft contained within a large horizontal stainless steel cylinder or cage. Arms on the shaft are attached to paddles or blades such that when the shaft turns, the grapes are moved and pressed against the side of the cylinder. Perforations on the walls of the cylinder allow for the juice (along with the skin, seeds, and pulpy material) to pass through into collection vats, whereas the stems gather at the end.

Crushing and maceration

Maceration:

- Maceration at low temperatures (<15°C) ordinarily results in only moderate pigment extraction and little fermentation. However, if the must is macerated at a low temperature (between 5°C and 15°C), but for longer time, extraction of anthocyanins and aroma and flavor compounds can be enhanced. This technique, called **cold maceration**, simulates the natural conditions in cooler wine-producing areas.

- For white wines, if a maceration step is performed, it is done at lower temperature and for much less time. Typically, only a few hours at 15°C is sufficient.

- For most white wines, however, the producers remove the seeds and skins immediately after crushing (i.e., **sans maceration**).

Initiating fermentations

- Two options exist for initiating the wine fermentation.

1. First, the fermentation may proceed entirely on its own, i.e., without the addition of a yeast starter culture. Winemakers sometimes refer to these fermentations as spontaneous or indigenous. The term, "natural" is also used to describe these fermentations. Except for temperature control, essentially no other restrictions or selective pressures are placed on the fermentation. Yeast growth, depending on the temperature, will generally occur rather quickly, with a relatively short lag phase.

2. The other option is to start the fermentation with a defined yeast starter culture selected by the winemaker. This option usually requires that the indigenous or autochthonous microbiota be inactivated or controlled, such that it does not compete or possibly interfere with the added culture. This is not, however, always the case, because it is still possible to add a starter culture even in the presence of the background microbiota. The use of wine starter cultures has now become commonplace, even among many traditional wine manufacturers.

Initiating fermentations

- The amount of sulfite added and when it is added varies depending on;
  - the condition of the grapes,
  - the microbial load,
  - must pH and acidity, and
  - the type of wine (red or white).

- Usually, SO_2 or sulfite salts are added to the must just after crushing.

- Musts from mature grapes that often contain high levels of wild yeast require more SO_2, but in general, about 80 mg/L is sufficient.

- Also, the lower the pH, the less sulfite is necessary for antimicrobial activity.

- Due to human health concerns, however, there are also regulations that dictate how much sulfite can be present in wine.

- In France and most of Europe, red and white wines must contain less than 160 mg/L or 210 mg/L, respectively.

- In the United States, the limits are 350 mg/L for both red and white wines.

- Sulfite warning labels are triggered at 10 mg/L.

Other treatments

- Besides sulfites, it is permissible to add other materials, to the must to enhance extraction, modify the composition, or promote fermentation.

- For example, pectic enzymes can added as process aids during crushing to facilitate extraction of juice from skins and later during pressing to improve clarification. This practice is quite common for white wines manufactured in the United States.

- It is not uncommon for some grapes, and juices from those grapes, to have either too low or too high of a pH. Thus, either acids, such as tartaric acid, or neutralizing salts, such as calcium carbonate, can be added to adjust must acidity.

- Finally, nutrients that enhance yeast growth and fermentation can be added. These yeast growth factors usually are added to white wine juices, since shorter extraction times may result in lower nutrient concentrations. Nutrients added to juices include mainly ammonium salts and various vitamins.

Separation and pressing

- After the maceration step, or in the case of most white wines, almost immediately after crushing, the juice is separated from the seeds, skins, and pulp (collectively referred to as the pomace).
- The juice that separates from the pomace simply by gravitational forces is called the **"free run"**.
- Screens are typically used to catch any large particles.
- The free run juice is pumped into vats or barrels.
- Since the free run juice contains less than 75% of the total juice volume and the rest is present within the pomace, the pomace is usually pressed to recover the remaining juice.

Separation and pressing

- Several types of presses and configurations are used.
- Hydraulic or pneumatic wine presses squeeze the juice from the pomace.
- Screw- or auger-type devices force the juice against perforated cylinder walls and have the additional advantage of being continuous.
- The so-called **first press juice** can be collected and either added back to the free run juice or kept as a separate portion.
- The free run fraction is considered to have an appreciably higher quality and is used for premium wines.
- Juices containing mixtures of free run and pressed fractions are used for somewhat lower quality wines.
- Finally, for white wine, the juice is clarified to remove any remaining solids.
- **Clarification** is done via settling and decantation, filtration, or centrifugation.

Fermentation

- The wine fermentation begins as soon as the grapes are crushed.
- However, when a starter culture is used and SO_2 is added to control the indigenous organisms, limited ethanol fermentation will occur prior to addition of the culture.
- **In the case of white wine production, the culture is added to the must after pressing and clarification**, **whereas for red wine, culture addition is done prior to seed and skin removal.** Thus, for red wines, fermentation occurs during maceration, just as it would for a spontaneous fermentation.
- Of course, the culture's main responsibility is to produce ethanol from sugars, but the criteria for culture selection actually includes many other properties (Slide no 17).
- The culture is either prepared directly as a rehydrated dried culture or it can be propagated in an active liquid form. When added to the must, it should provide about 10^6 cells per ml.

Fermentation

- Traditionally, fermentation was conducted in large wooden barrels or concrete tanks, but most wineries now use stainless steel tanks with facilities for temperature control, cleaning-in-place, and other features for process management.

- The temperature of incubation depends on the type of wine being produced.

- In general, white wines are fermented at lower temperatures than red wines.
  - For example, many wineries control the temperature between 7°C and 20°C for white wine and between 20°C and 30°C for red wines.

- White wines are generally fermented at 10-18°C for 7-14 days or more, where the lower temperature and slower fermentation rate favour the retention of volatile flavour compounds.

- Red wines are fermented for about 7 days at 20-30°C, where the higher temperature is necessary to extract colour from the grape skins.

Adjustments and Blending

- After the fermentation is complete, the wine will contain little or no sugar and about 12% to 14% ethanol.
- Still, because of differences in grape composition, microbiota, and wine manufacturing practices, variations in wine composition and sensory quality are to be expected.
- Therefore, adjusting the wine after fermentation (or in some cases, before) is a normal step.
- The pH and acidity, in particular, can vary markedly, as can the color and flavor.
- Therefore, some wineries adjust the acidity of wine by acidification or deacidification steps (e.g., by adding acids or neutralizing agents).
- When acidity of wine or must is due to malic acid, deacidification is managed via the malolactic fermentation.
- Adjustment to wine color and flavor can also be done, if legally permitted, by filtration and enzyme treatments, respectively. Filtration techniques, for example, are most often used to “decolorize” wine by removing undesirable pigments.

Adjustments and Blending

- Most modern wineries have many individual vats of wine.
- Each one is unique, in that a particular vat may contain wine made from grapes harvested at a time or place different from the grapes in a neighboring vat.
- Wines within a single winery may be made from different grape varieties.
- Therefore, another common procedure, especially for premium wines, is to blend different wines to optimize or enhance the organoleptic properties.
- Blending also produces wines with consistent flavor, aroma, and color from year to year.

Clarification

- Traditionally, wine was clarified by simply allowing the sediment, containing the yeasts and bacterial cells, as well as precipitated material, to settle naturally in barrels or vats. The wine could then be removed from the sediment (or "lees") by decantation. This process, called **"racking"**, is usually done for the first time after three to six weeks following the end of the fermentation. Racking can be repeated several times over a period of weeks or months until the wine is nearly crystal clear. During the racking step, the wine is also aged. Racking can now be done in enclosed tanks using automated transferring systems.

- **Filtration** is another method used to clarify wine. This can be especially effective if **fining agents**, such as bentonite, albumin, or gelatin, are used as filtration aids.

- If micro-pore filtration membranes are used, it is even possible to nearly sterilize wines.

- Clarification may occur after racking or after aging. (This filtration process is similar to that described for beer.)

Clarification

- In contrast to removing the sediment shortly after the fermentation has ended, some wines are intentionally left in contact with the lees for an extended time before the first racking occurs. This traditional maturing practice, known as "**sur lie**".

- This practice enhances the flavor, character, mouth feel, and complexity of the wine. It is more common for white wines than for reds.

Aging

- During aging, hundreds of enzymatic, microbiological, and chemical reactions occur, and as many as 400 to 600 volatiles, including esters, aldehydes, higher alcohols, ketones, fatty acids, lactones, thiols, and other compounds are formed.

- Moreover, the wine interacts with the wood and wood constituents in the barrel, oxygen in the air, and even the cork.

- It is important to recognize that not all of these reactions are beneficial in terms of wine quality, and some wines may actually deteriorate during aging. In fact, long aging is not good for most wines.

Table 11.4 Effects of aging on wine.

Reaction or step	Effects
Tannin precipitation	Color darkens; astringency increases initially, then decreases
Wood cooperage	Phenolic and other flavors extracted
Ester hydrolysis	Fruitiness decreases
Oxidation	Browning and flavor reactions induced
Evaporation	Concentrates non-volatile solutes; color and flavor intensifies, but aroma volatiles decrease