WINE YEAST & FERMENTATION

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The conversion of glucose and fructose into ethyl alcohol is a multi-step, biochemical process. Several different enzymes are required for the conversion and yeast provides the needed enzymes. About a dozen different steps are involved, so there are lots of opportunities for problems. Large wineries avoid fermentation problems by doing extensive testing at each stage of the fermentation process. Home winemakers try to avoid problems by measuring temperature and Brix and by smelling and tasting their fermentations often.

In general, wine yeasts are in the genus Saccharomyces and practically all commercial wine yeast strains are either Saccharomyces cerevisiae or Saccharomyces bayanus. Some strains of yeast are quite vigorous and usually ferment to dryness. Other strains produce sluggish fermentations and often leave some residual sugar. Some strains are sensitive to excessively high or low fermentation temperatures. Some strains of yeast require more nutrients or more nitrogen than other strains. Some strains produce excessive amounts of foam and can make a big mess.

There are significant differences in the fermentation characteristics of the different strains of yeast, but byproducts produced by the yeasts do not make **large** contributions to the smell or taste of aged wines (see page 181 of Principles and Practices of Winemaking).

Selecting the "right" strain of yeast depends mostly on the style of wine being made and the equipment available. Yeast suitable for making table wines should have the following characteristics. (1) It should produce a vigorous fermentation and not leave residual sugar in the wine. (2) It should ferment in a predictable and reproducible way. (3) It should tolerate high alcohol levels and high sulfur dioxide levels. (4) The yeast should not produce off-odors or off-flavors.

Active, dry yeast consists of live cells so it must be handled with care. When stored in a cool dry place, unopened packages of dry yeast will remain viable for at least two years. But dry yeast is sensitive to water vapor so once a package has been opened, the yeast should be used within a few months.

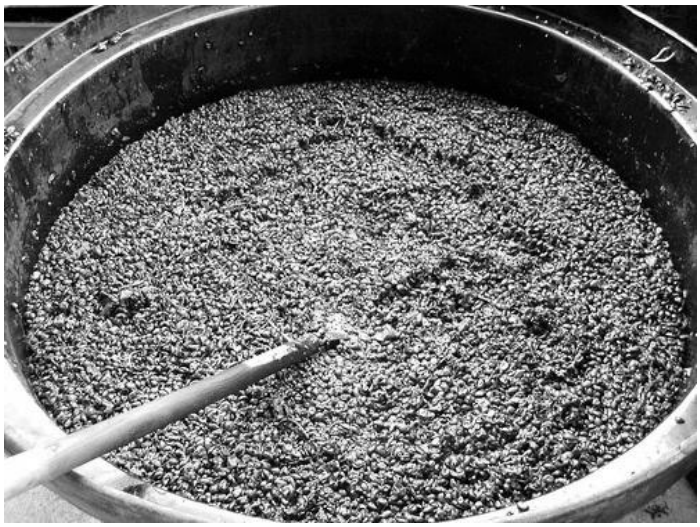
Old, dry yeast can be used to remove ethyl acetate smells from tainted wine and it can also be used to remove excessive amounts of dissolved copper or other metals from wine. So, experienced winemakers do not throw their old, dry yeast away. They save their old yeast so it can be used as a fining material if needed.

Yeast Growth Requirements

At the peak of fermentation, there are more than 50 million yeast cells per milliliter of liquid, and the starting yeast cells must have access to nitrogen, oxygen, vitamins, minerals and other growth factors in order to produce such a large population. Saccharomyces yeasts tolerate high sugar concentrations better than other types of yeast. Even so, large amounts of sugar in high Brix juice can inhibit Saccharomyces yeast growth due to osmotic pressure. So, high Brix musts are much more likely to "stick" than musts containing normal amounts of sugar. In addition, high Brix musts often start fermentation slowly because of the high sugar content. Consequently, many home winemakers add two grams per gallon of dry yeast to high Brix fermentations which is twice the normal amount.

Alcohol decreases the flexibility of yeast cell membranes. Membrane integrity is impaired, nitrogen intake through the cell wall is reduced and cell metabolism is changed. So, all types of yeast are vulnerable to high alcohol levels. High fermentation temperatures, low juice pH, nitrogen deficiency and vitamin deficiency act synergistically with alcohol and these factors in combination with high alcohol levels can be toxic to wine yeast.

Carbon dioxide gas in concentrations above about 0.2 atmospheres is toxic to wine yeast and carbon dioxide toxicity is an important consideration when a winemaker is trying to restart a stuck fermentation. Racking the stuck wine with considerable splashing to blow off some carbon dioxide gas is the usual remedy applied by home winemakers.



Yeast Needs Oxygen

Yeast needs oxygen to produce lipids and sterols, which are important constituents of cell membranes. So, oxygen is an essential yeast nutrient and without adequate initial oxygen, yeast multiplication is usually limited to four to five generations. Aerobically grown yeast cells contain more unsaturated fatty acids and more sterol and aerobically grown yeast exhibits improved viability and fermentation characteristics.

Yeast can reproduce rapidly when sufficient oxygen is available, and populations can double in a few hours when conditions are just right. This rapid period of yeast growth is called the exponential growth phase. Rapid cell growth occurs during the exponential growth phase and an enormous yeast population can develop in 24 hours. The yeast is using most of the resources to produce more cells and little alcohol is produced. The situation is different when oxygen is restricted. Then, yeast cell reproduction is much slower, but the yeast produces larger amounts of ethyl alcohol.

Having oxygen available early in the fermentation process is always desirable from a winemaking point of view. Yeast cells then multiply rapidly, and a large yeast population is quickly produced. A lack of oxygen is seldom a problem when typical home winemaking conditions exist. The quantity of oxygen needed by the yeast is small, and enough oxygen is introduced when grapes are subjected to the normal winemaking processes of crushing, pressing, etc. Note that the extensive use of carbon dioxide or nitrogen gas or adding ascorbic acid when the grapes are crushed can significantly reduce the amount of dissolved oxygen in the starting juice.

Yeast Needs Nitrogen

Yeast must also have nitrogen and phosphate in order to divide and produce new cells. In addition, yeast can produce excessive amounts of hydrogen sulfide (stinking fermentations) when they lack sufficient nitrogen. Normally, grapes contain enough nitrogen to meet the yeast requirements. However, vineyards needing fertilization often produce fruit that is excessively low in nitrogen and phosphate content and then the yeast may have problems producing the large number of cells needed to complete fermentation. Large wineries measure the nitrogen content of each batch before fermentation is started. Home winemakers simply add small quantities of diammonium phosphate (DAP) or other sources of nitrogen to juice or must. One or two grams of DAP per gallon of juice is the usual amount. Excessive amounts of nitrogen in any fermentation are undesirable. So, the timing of the DAP addition is important and two or three small additions spaced a day apart are preferable to one large dose. But, all nitrogen additions should be made during the first half of the fermentation because a

significant problem can develop when nitrogen is added too late. Near the end of fermentation, considerable alcohol has accumulated and the alcohol acts on the membrane of the yeast cells and prevents the added nitrogen form entering the yeast cells. Now, the yeast does not benefit from the added nitrogen and the fermentation may stick. Then the unhappy winemaker has a stuck wine that contains too much sugar and too much nitrogen. To avoid this problem, all winemakers monitor their fermentations carefully and correct any nitrogen deficiencies early in the fermentation cycle before a large amount of alcohol has accumulated. For the same reason, simply adding nitrogen to a stuck fermentation seldom produces successful results.

Yeast Needs Nutrients

Yeast also needs an assortment of vitamins, minerals and other cell growth factors. However, very small quantities of these substances are required, so winemakers often call these materials "micro nutrients." Most grapes contain adequate quantities of these nutrients, but some vineyards consistently produce grapes that are deficient in a particular growth factor. Must made from rotten grapes contain large populations of undesirable microorganisms and these musts are often deficient in vitamins. The vitamin thiamine is necessary for yeast growth, and a problem often arises when large amounts of sulfur dioxide are added to control the microorganisms because the added sulfur dioxide deactivates thiamine. Home winemakers try to anticipate and avoid nutrient deficiency fermentation problems by adding small amounts of a complete "yeast food" to the must. Several commercial products such as SuperFood, Fermaid, Go-Ferm, etc. are produced specifically to supply yeast with nitrogen, amino acids and all of the other necessary micro nutrients.

Preparing Dry Yeast

Enough yeast should be added to the must so the large population of yeast cells needed to complete fermentation can be reached after four or five generations. This rapid population growth is desirable so the inoculated yeast can quickly overwhelm any indigenous micro-flora present. One or two grams of dry yeast per gallon of must are normal inoculation amounts. However, increases in the starting yeast volume are often made when high Brix musts are being fermented.

Dry yeast should be hydrated at the temperature recommended by the supplier. Many cells die if rehydration temperature is too warm or too cold, so a thermometer should be used. After rehydration, the yeast should be added to the must within 20-30 minutes. For longer wait times, a source of sugar should be added to the rehydrated yeast to prevent the yeast cells from going into the decline phase prematurely. Many home winemakers do not realize that yeast is very sensitive to temperature shock. Rapid temperature changes of more than fifteen degrees should always be avoided. So, warm, rehydrated yeast solutions should be tempered with two or three small additions of cold juice before the rehydrated yeast is added to the main batch. This tempering is particularly important when rehydrated yeast is being added to very cold musts or juice.