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Considerations for Starting a Winery

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Impact Statement

This publication is for anyone who has ever considered entering the wine industry. The goal of this publication is to provide information about requirements and procedures for starting a winery. It is not a "how-to" manual but rather is designed to serve as a starting point to investigate the many aspects of owning and operating a winery. Although the manuscript frequently refers to procedures for starting a winery in Arkansas, the concepts presented are applicable throughout the U.S. Detailed economic information on starting a winery is covered in a companion publication. Both publications are part of a project supported by the National Research Initiative of the USDA Cooperative State Research, Education and Extension Service, grant number #2006-55618-17203. The purpose of this grant is to provide research and training to help owners of small- and medium-sized farms in Arkansas and throughout the U.S. explore the potential for grapes as an alternative and sustainable crop.

Introduction

The notion of establishing a winery can be extremely romantic. Winery images presented in the media are often beautiful landscapes, impressive homes and buildings, and attractive revelers enjoying lavish feasts or celebrations in vineyard surroundings. These scenes evoke a sense of an elegant, sophisticated, luxurious, even opulent life style. The reality is that every successful winery is the product of a great deal of determination, technical expertise, hard work, persistence and good luck, or at least a notable lack of bad luck.

This publication is for anyone who has ever considered entering the wine industry. The goal of this publication is to provide information about requirements, procedures and equipment for starting a winery. It is not designed as a "how-to" manual but rather is designed to serve as a starting point as you investigate the many aspects of owning and operating a winery. Major winemaking procedures are discussed so that the reader can gain an appreciation of the investments in time, money and equipment necessary to establish a winery. Although the manuscript frequently refers to procedures for starting a winery in Arkansas, the concepts presented are applicable throughout the U.S.

Throughout this presentation additional references are identified. These references include research articles, Web sites and reference materials that can provide more information on starting and operating a winery. They generally can be found at local libraries, bookstores, and through Internet sources.

Anyone considering entering the wine industry is strongly advised to visit local established wineries and talk to the owners. They can provide first-hand information about such things as state and local laws, sources of grapes, winery location, and other issues. No one can give better information than local winery owners. Although it may seem strange to seek advice from future competitors, most established wineries consider growth in the industry is a good thing and they are more than willing to help those starting out.

Enhancing the productivity and profitability of the wine and juice industry in Arkansas and the region has been the focus of research in the Viticulture and Enology Program of the University of Arkansas Division of Agriculture's Institute of Food Science and Engineering and Food Science Department. A brief description of this work can be found in Appendix A.

Also included is a list of some of the publications and presentations produced from this work with results most directly affecting the wine and juice industry. A more complete publication list along with links to many of the publications can be found at the UA Viticulture and Enology Web site: http://www.uark.edu/depts/ifse/grapeprog/default.html

Winery Location and Design

Location is the most important factor when establishing a small winery. Make sure the winery and vineyard (if a vineyard is planned) are visible from a major road. Attractive signs to lead customers to the facilities are a necessity. Typically, most wine sales will occur at the winery since on-site sales are the most profitable for small wineries; therefore, the winery must be located in a county that allows wine production and alcohol sales (See Appendix B for dry/wet designations of Arkansas counties).

The site selected for the winery must have room for the buildings required by the small start-up operation, but also should have room to allow for growth. Adequate space for parking, both for employees and customers, must be a consideration. If marketing plans include events like festivals, dinners, or other special activities attracting a lot of people at once, plans should be made to handle the extra traffic and parking.

The winery needs to be located near a vineyard or with ready access to a source of grapes. Grape quality begins to deteriorate quickly once the grapes are harvested so the faster they can be moved from the vineyard to the winery, the better. Because the winery will need to receive frequent deliveries of grapes, bottling supplies, and other materials and to ship product for distribution, the location should be easily accessible by larger vehicles. Easy access to the winery is also important to assure a sufficient pool of employees and to allow service personnel, like electricians, plumbers, mechanics, and refrigeration technicians, to reach the facility in a timely fashion.

A winery needs reliable access to utilities. Reliable access to 220-V, three-phase electrical power is a requirement and if high-power equipment like steam generators will be used, 480-V power will be needed. Wineries are

water-intensive enterprises. Major water use areas are in the fermentation tanks, barrel washing, barrel soaking, bottling line, and crushing. This means the location chosen for the winery should have access to a consistent supply of good quality water. In addition to water requirements for making the wine, assuring a consistent supply of water will be important in obtaining fire insurance.

Wineries usually have a design plan that includes areas for the various stages of winemaking (receiving, fermentation, and bottling); sales and tasting rooms; office space; rest rooms; laboratory; separate storage areas for glass, bottling supplies, and chemicals; and a bonded area (for storing the wine while under a TTB bond—explained in the section "What Kind of Wine Business Will You Have?"). Careful consideration must be given to the layout of these various areas (Bailey et al., 2002). Grouping the winemaker's office, laboratory and tasting room is often efficient. However, in a smaller winery with limited personnel, it may be important for the winemaker's office to be placed where operations like receiving and processing can be easily overseen. Placing the tasting room away from processing areas assures that visitors are not bothered by the noise or the smells of the winemaking and are safely removed from equipment hazards.

Figure 1. Equipment layout and workflow are critical issues in designing a winery. The winery should have an efficient layout suitable to winemaking and be built to accommodate expansion, when it is needed. (Photo courtesy of Prospero Equipment Corp.)

A properly designed building will make wine production easier and enhance the winery experience for guests. Often, sites are chosen because they have a building or environmental feature that is desirable. As the plans develop, the owner discovers the site is difficult to adapt to accommodate the necessary equipment or to facilitate the winemaking process. Established wineries should be visited before selecting a building to rent or developing a design to build.

Regardless of whether the winery will be in a newly constructed building or a renovated existing facility, equipment layout and workflow are critical factors in designing the winery. Considerations will include efficient workflow, the specific requirements of the wine style(s) being produced, access to production equipment for operation and maintenance, lighting, energy efficiency, and forklift access. Safety of personnel and visitors must always be a key consideration in preparing layout and design plans.

Turning Your Concept into a Reality

Prepared by Mike Heilman

Financially speaking, the old joke often applies: "Know how to make a small fortune in the winery business? Start with a large fortune." Indeed, many who set out to establish a winery begin with very deep pockets. Probably an even larger number are motivated less by an expectation of profit than by the idea of obtaining some form of psychic income or quality of life fulfillment. If one desires to become the proud proprietor of a wine estate, preparation of a business plan will be required.

A business plan is essential if outside financing is sought for the venture. The business plan should demonstrate to a banker or other prospective investor how the winery will be able to provide the required return, and how much that required return should be, based on the best possible assessment of the risks involved.

Preparation of a business plan requires competent financial counsel. If you do not have the necessary experience and knowledge yourself, your first investment should be in competent, professional advice. The continued use of the word "competent" is meant to underscore the importance of having a knowledgeable and experienced resource. In the best of worlds, your enterprise will be one filled with uncertainty and several sources of risk affecting both returns and the ultimate success of the winery itself. Competent financial counsel is an absolute requirement.

While examining the financial aspects of establishing and operating the winery is a necessary part of a business plan, there is much more involved. The business plan should serve as the strategic plan for the development and operation of the business, the basic tool that you should use to help you think through the development of your business, and a detailed plan for managing your business. Its preparation helps ensure that you have considered different options and anticipated potential difficulties. It should be an evolving instrument, used to evaluate your progress against your planned business goals, and updated and modified for operational and strategic planning purposes as the business environment changes. In this case, knowledge is power. The information developed can make it much easier to overcome various obstacles to the entry and financial success of your enterprise. The business plan is an important tool to reduce the uncertainty involved in decision making and thus reduce risk. However, it is important to remember that while the aim of the

business plan is to reduce uncertainty by quantifying the various inputs, outputs and results of the enterprise, these numbers are assumptions about an unknown future.

The Business Plan

The comprehensive business plan should include detailed descriptions of the organization of the business; the product(s) to be produced and the production process; market analysis and the marketing plan; the financial plan; and your enterprise's operational characteristics and your management plan.

One of the first considerations should be exactly which form of business organization should be used. The choice of business organization affects the ease of its formation; your potential financial liability; accounting and tax reporting requirements; ability to raise external financing, if needed; and succession of ownership.

Another early determination is what types of products and services will be offered by your winery. General economic conditions and specific economic and business conditions affecting the wine industry should be considered. Numerous governmental issues and licensing requirements must be satisfied and may affect this determination. Still other considerations are how accessible is the location to the customer base, what exactly is that customer base, and how will that consumer base be affected by economic changes? The first production concern is deciding the initial level of production to undertake with some idea about any subsequent increases in production. Which varieties of grapes will be used, and how will these grapes be obtained? Will a new vineyard be established? If so, the costs of establishing the vineyard should be detailed. Full production from a new vineyard could take up to five years. If you are not prepared to establish a vineyard or to wait until your own grapes are available, will grapes simply be purchased from other growers? Are such growers available and willing to contract to supply the needed grapes? Grape yields, and subsequently the price, are extremely variable. In addition, the suitability of the available workforce should be determined. A determination of the needed facilities and equipment and their cost must be made.

Marketing concerns will include identifying your competitors and why a prospective customer would buy your product rather than your competitor's. How do you differentiate your product and service from that of your competitors? How exactly will you sell your product? How will you promote it? A sales forecast needs to be established. What will be the price of your

product? Will the market for the product and the costs of producing it remain relatively stable? The bottom line question is whether the product can be produced and sold at a profit.

Financial considerations are involved in all of the decisions above. Establishing a winery is a capital intensive business; a large amount of the costs are fixed costs. That is, the costs will be incurred whether your production level is very low or high. A break-even analysis can determine the level of production—and sales—necessary to break even (avoid losing money). The forecast of sales (and the ability to produce that level of sales) obviously needs to be above that level. The business plan will include pro forma financial statements that will describe the projected profitability and the financial health (at various times) of the enterprise. The projected cash flows will allow determination of the need for additional financing as the enterprise grows and matures.

Various templates for developing a business plan are available online and many entities, both governmental and educational, can provide assistance with this aspect of starting your business. However, to reemphasize what has already been stated, competent financial counsel is required to develop these pro forma financial statements. More importantly, competent managerial skill in operating a business; a knowledge of the science and art of wine making; and an understanding of the science of grape growing (and the general acquiescence of Mother Nature) are necessary for the success of the winery enterprise. For those with a creative, innovative or emotional desire to establish a winery, understand that in this case, although *in vino veritas*, the truth is determination, hard work, and persistence.

What Kind of Wine Business Will You Have?

The U.S. Department of the Treasury's Alcohol and Tobacco Tax and Trade Bureau (TTB) is responsible for administrating the Federal Alcohol Administration (FAA) Act. This Act was passed at the end of Prohibition to protect the newly legalized alcoholic beverage industry from unfair practices and to protect consumers from deceptive labeling and advertising. Anyone who wants to wholesale, import, or produce and sell alcoholic beverages must qualify for a permit under the FAA Act and obtain prior approval of their labels from TTB.

One of TTB's responsibilities is to assure that wine businesses will be capable of paying the taxes due on the wine they produce, store, import, or

handle. In order to make this assurance, each wine business is required to place money into a bond to assure this payment. For this reason wineries and wholesalers are described as being "bonded." Wineries may place the actual money for the taxes in a bond account or they may choose to use a bonding agency (basically, an insurance policy). The amount of taxes, and therefore the bond required, is calculated based on the capacity of the winery and on the alcohol content of the wine(s). As a winery grows and capacity increases, so does the amount required for the bond. TTB's Web site provides detailed information on establishing and maintaining a bonded premise.

There are a number of ways a person may become part of the wine industry. The choice of which is best will depend on factors such as desired level of involvement and financial resources available. In some cases, it might be desirable to try being part of the wine industry before investing large amounts of time and money in establishing a winery. TTB recognizes these different levels of involvement and has permits appropriate for each. These levels are described briefly below. Additional information and the forms for obtaining the various federal permits for each type of wine business can be found on the TTB Web site (http://www.ttb.gov/wine/federal_app.shtml).

Bonded Winery: When a company qualifies as a stand-alone winery, it is responsible for all production activities that take place on the bonded premises. This includes record keeping, documenting the winery's activities and filing reports about these activities to TTB. It also generally includes obtaining label approval for the wine prior to bottling and paying excise tax on the wine. The owner of the winery has the expense for all necessary winemaking equipment, costs of operation, and buying or renting the property.

Alternating Proprietor: Some people would like to make wine for commercial purposes, but either do not have the interest or the financial ability to build or buy a winery of their own. By sharing a bonded winery facility with another company (or companies) on an alternating basis, they are able to produce their wine and qualify with TTB as an Alternating Proprietor winery. The wine company which owns or controls the building is known by TTB as the "Host," and the other wineries which share the premises are referred to as "Tenants" or "Alternators."

In most situations, the Host agrees to rent space and equipment to the Tenant. This allows existing wineries to use excess space and capacity and gives new entrants to the wine business an opportunity to begin on a small scale without investing in a winery building and all of the necessary winemaking equipment.

The Host and the Tenant wineries are each fully qualified as bonded wineries with TTB. Each company is responsible for its own production, record keeping, reporting, labeling, and taxes, independent of one another. The tenant proprietor must direct and be fully responsible for those things that are usual and customary for the production, bottling, and storage of their wine and for managing their business.

Custom Crush: Those just entering the wine business may decide they would prefer to focus their energy and capital on establishing their vineyards and developing markets for their wines rather than doing the actual winemaking. Another situation may exist when a person has grapes or other winemaking materials that they would like to have made into wine, but would prefer that someone else make the wine for them. In both situations, a Custom Crush Winery may be the best approach to getting the wine made. In this arrangement, a bonded Custom Crush winery supplies the space, equipment, and trained personnel to make the wine. The person or companies with the raw materials are known as the Custom Crush Clients and qualify with TTB as Wholesalers.

The Custom Crush winery must be fully qualified as a bonded winery. It is responsible for all production, records, reports, labeling, and taxes, even though it is producing the wine for a customer. The winery that bottles the wine obtains approval from TTB for the wine's label, and the wine premises that remove the wine from bond pay the Federal excise tax on the wine, regardless of who owns the wine. The producing winery incurs the expenses for winemaking equipment and winery premises.

In most cases, the Custom Crush Client needs to qualify for a Federal Basic Permit as a Wholesale Liquor Dealer (Wholesaler) under the FAA Act. A custom crush client Wholesaler has minimal TTB record-keeping requirements. The custom crush client Wholesaler has no production, labeling, tax, or reporting responsibilities. All of these matters are the responsibility of the bonded winery or wineries with whom the customer is working to have the wine produced, labeled, and taxpaid.

Bonded Wine Cellar: Some companies will qualify with TTB as a Bonded Wine Cellar. This is a bonded storage warehouse established to store, blend, or bottle untaxpaid wine. (Note: the Internal Revenue Code identifies all premises where untaxpaid wine operations take place as "bonded wine cellars" and those premises where wine is produced as "bonded wineries.")

Regulatory Approval

Regardless of the type of wine business chosen, approvals in the form of licenses, permits, and bonds will be required before operations begin. In Arkansas, as in many other states, counties are designated as "wet" or "dry" based on the results of local option elections. These elections may be held in conjunction with the November general elections so the wet/dry status of a county may change. In Arkansas, retail sales and manufacture of alcoholic beverages are legal in wet counties. In dry counties, only private clubs may obtain permits for serving alcoholic beverages. However, many of the wet counties have dry areas such as townships or cities within their boundaries. It is important to check with the Alcoholic Beverage Control in the state where you are planning to open a winery to determine the wet/dry status for the proposed winery location. A map showing the wet/dry status of Arkansas counties as of February 2007 is provided in Appendix B. Remember, however, that this status is subject to change and should be investigated before proceeding with plans to start a winery.

Before a winery can begin operations, assurances that all federal and state regulations are met will be required as well as appropriate approvals from local regulators. These are discussed briefly below. A person considering starting a wine business is strongly encouraged to make contact with each of these authorities/agencies early in the start-up planning process to ensure appropriate approvals and permits are in place before beginning operation.

1. Approval by local authorities may be required by some jurisdictions - If the winery will be located within the city limits, check with the city government about what city permits are required. City regulations regarding waste and wastewater disposal, zoning, and traffic may be considerations when establishing a winery at a specific location. If the winery will be outside of the city limits, county permits/approvals may be needed. City and county government offices should be consulted about what type of approvals are required. Contact information for these offices can usually be found in the white pages of local telephone books.

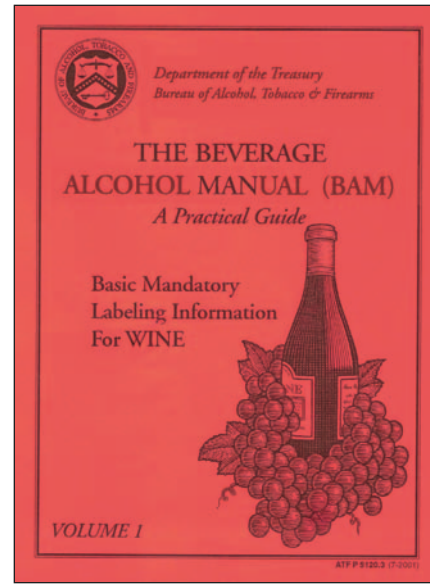
2. Compliance with Alcohol and Tobacco Tax and Trade Bureau (TTB) requirements - Federal law requires that anyone wishing to conduct wine operations (other than as a home winemaker) must first establish premises, obtain a bond and receive permission from TTB. Information regarding the

required forms that must be filed to start a wine business, contacts for help, and copies of the regulations that must be met can be found at TTB's Web site located at http://www.ttb.gov/wine/index.shtml

3. Compliance with Alcoholic Beverage Control (ABC) requirements – Almost all states have an agency within the state government with responsibility for regulating the establishments that make and sell alcoholic beverages. In Arkansas, the Alcoholic Beverage Control Division of the Arkansas Department of Finance and Administration is responsible for regulation, supervision, and control of the manufacture, distribution, and sale of all alcoholic beverages and the issuance and regulation of permits pertaining to these activities. The ABC Division is located at: 1515 West Seventh Street, Suite 503, Little Rock, Ark. 72201.
   Their Web site (http://www.arkansas.gov/dfa/abc_administration/documents/abc_regs.pdf) provides links to the official regulations and additional contact information. Contact information for this agency in other states can generally be found by searching for alcoholic beverages on the state government Web site.

4. Individual label approval – The Federal Alcohol Administration (FAA) Act requires that alcoholic beverage labels provide the consumer with adequate information regarding the product's identity and prohibits the use of misleading information on these labels. The TTB administers these regulations. This means that wine must carry a label that has received a certificate of label approval (COLA) from the TTB. Do not bottle or print labels prior to TTB approval of the proposed label. Information on how to apply for a COLA for a label(s) is presented in the labeling section of the TTB Web site (http://www.ttb.gov/labeling/index.shtml).

An overview of the information that may be placed on a wine label is provided in Appendix D. Detailed guidance for preparing a label can be found in "The Beverage Alcohol Manual (BAM) - A Practical Guide: Basic Mandatory Labeling Information for Wine" (Publication No. TTB P 5120.3). This publication provides specifics on the required information and appropriate formats for label information presentation. This manual can be obtained from TTB and also is available at http://www.ttb.gov/wine/bam.shtml



5. Label registration and approval from the state Department of Finance and Administration. Although these rules may vary slightly by state, most states have some requirements for label approval. Requirements and procedures for producing and marketing wine in Arkansas are contained in the Arkansas Alcoholic Beverage Control regulations which can be found at http://www.arkansas.gov/dfa/abc_administration/documents/abc_regs.pdf

Other Federal Agencies with Regulatory Authority Affecting Wineries

Food and Drug Administration (FDA). A winery is a food processing plant and, as such, is subject to FDA regulations for such facilities. Two sets of FDA regulations are especially important for operators of wineries. The first of these are the current Good Manufacturing Practices (GMPs). To produce and sell food and beverages for human consumption a business must comply with the GMPs. These regulations were established to assure that facilities and procedures used to manufacture, process, package, and hold foods conform with standards that guarantee the food is safe and has been prepared and handled under sanitary conditions. Included in the GMPs are requirements for the following areas:

- Facilities and grounds
- Equipment and procedures
- Facility sanitation
- Sanitary operations
- Processes and controls
- Personnel

Specific information on requirements contained in the GMPs can be found on the FDA's web site: www.fda.gov/cdrh/devadvice/32.html

The FDA also is responsible for enforcing the Bioterrorism Act of 2002. This act requires that all plants that manufacture, process, pack, or hold food register with the FDA. This registration was established to help FDA determine the location and source of a potential bioterrorism incident or an outbreak of foodborne illness and to quickly notify the facilities affected. Registration can be done online at http://www.cfsan.fda.gov/~furls/ovffreg.html

Environmental Protection Agency (EPA). Wineries produce large amounts of waste materials and discharges which have the potential for polluting the environment. The EPA has established rules designed to verify that all materials are handled properly and that procedures used for waste disposal are safe for the environment. Areas regulated by the EPA which can affect wineries include water pollution control; clean air; insecticide, fungicide, and rodenticide usage; and solid waste disposal.

Occupational Safety and Health Administration (OSHA). The role of OSHA is to assure the safety and health of workers. Examples of hazards to workers in wineries include dangers associated with using equipment that has belts or is under pressure, lifting heavy objects, hazardous wet surfaces, work in confined spaces, and use of chemicals for cleaning and sanitizing facilities and equipment. Wineries must comply with all OSHA regulations for employee safety.

Winemaking Plan

Regardless of your level of involvement in making the wines, it is important that you have an understanding of the process of winemaking. It is only through a thorough understanding of the procedures and equipment involved in this process that a potential winery owner can establish an efficient operation.

The making, aging, and marketing of high-quality wine can be an expensive and complicated process and requires a winemaking plan for each type of wine that will be produced. Before a plan can be made, it is necessary to determine the type of wine(s) to be produced. Although wine can be made from most fruits and some vegetables, this discussion will concentrate on making wines from grapes.

Wines are generally classified primarily on differences in the way they are made and their alcohol content (Vine et al., 1997). These classifications are defined by TTB and are the basis for the assessment of Federal Excise Taxes (FET). All wines, regardless of their classification must remain in bond at the winery until the FET is paid. Wine classifications include:

- Table wines – wines designed for use at the table as a complement to good food. Table wines are usually identified either by the variety of grape used in making the wine (varietals) or by the geographical region of origin (generics). The use of varietal names, like Chardonnay, Savignon blanc, and Merlot, is most common in the United States. TTB requires that table wines have an alcohol content of 14% or less. The FET for table wines is assessed on a sliding scale based on the winery's production volume.
- Effervescent wine – wine that bubbles. TTB designates two different types of wines within this category. Sparkling wine results from a secondary fermentation that occurs after the wine is sealed in the bottle. Carbonated wine is wine made effervescent with carbon dioxide not resulting from a secondary fermentation. The pressure produced in the bottle by the gas

requires the use of heavier bottles, special closures, and skilled handling. FET rates are the same for all producers of sparkling wine regardless of production volume. However, the rates differ depending on whether the effervescence is natural or due to carbonation.

- Dessert wine – usually considered wines consumed with, or in place of, dessert. By TTB's definition, dessert wines are wines with alcohol content in the range of 14-24% by volume. These are generally made by the addition of grape brandy to fermenting juice. Wines having added brandy are sometimes referred to as "fortified." Some states have specific rules about making these wines in addition to requirements for general winemaking. Because of their higher alcohol content, tax rates are higher on fortified wines than on table wines; however, makers of fortified wines are taxed at the same rate regardless of production volume.
- Aperitif wine – wines designed to serve as appetizers. Aperitif wines have an alcohol content of not less than 15 percent by volume, are compounded from grape wine containing added brandy or alcohol, and flavored with herbs and other natural aromatic flavoring materials. Aperitif wines are taxed at the same rate as dessert wines.

The first requirement for making wine is a suitable grape species. Red wines are made from red or dark-skin grapes while white wines are made from white grapes. Sometimes, white and blush wines are made by pressing red grapes rather than fermenting the juice with the skins.

If both a vineyard and a winery are being established, decisions must be made about the types of grapes to be grown in the vineyard. There are several factors that determine where various species and cultivars of grapes can be grown. These include but are not limited to site, soil, climate, and disease. In Arkansas, climate is probably the most significant factor in determining which grapes can be grown. The winter weather can vary from mild to extremely cold and these fluctuations in temperature can result in serious injury to grapes, especially *Vitis vinifera* and *V. rotundifolia* (muscadines) in the northwest and north-central parts of Arkansas. Summers in Arkansas can be extremely hot and humid and therefore conducive to growth of grape pathogens. For more information on selecting the best grape species for your specific site, contact your county Extension office or the viticulture or grape specialist in your state.

The character and quality of the wine is determined by 1) the chemical composition of the grapes, which depends to a large extent on cultivar, site, season, grape cultural conditions, canopy-management and fruit maturity;

2) the fermentation style and method; and 3) the changes that occur naturally, or are made to occur, during the post-fermentation and aging period (Amerine et al., 1982). The best wineries are designed to transform the grapes into must or juice in a minimum amount of time to prevent oxidation.

Making wine from any grape cultivar involves the process of fermentation, which is converting the sugar (glucose and fructose) in the grape juice into alcohol and carbon dioxide.

While there is no single, all-inclusive process for winemaking, there are a series of steps or stages that are generally followed. A discussion of the steps involved in both white and red wine production follows (See also Figure 2).

Harvesting and Handling

Sound grapes should be harvested by hand or machine at the point of desired fruit maturity. Once harvested, it is critical that the fruit is handled in a manner that will prevent quality deterioration. Juice from damaged fruit is subject to changes due to enzymatic oxidation and spoilage that could cause poor wine color and produce off flavors.

One factor that affects the rate of fruit breakdown is the temperature of the fruit at harvest. The higher the fruit temperature at harvest, the faster undesirable reactions occur. Since most wine grapes are machine harvested, the ideal situation is for vineyards to be located near the winery so that processing of the grapes can begin as quickly as possible. If the grapes must be transported long distances, they need to be crushed and chilled in a must chiller before transportation. In some cases, when the vineyard is 4 to 6 hours away from the winery, mechanical harvesting at night, while the grapes are cool, can be adequate to delay fruit deterioration.

Low levels of sulfur dioxide may be added during mechanical harvesting to delay enzymatic oxidation and suppress unwanted yeast and bacterial growth (Morris, 1983).

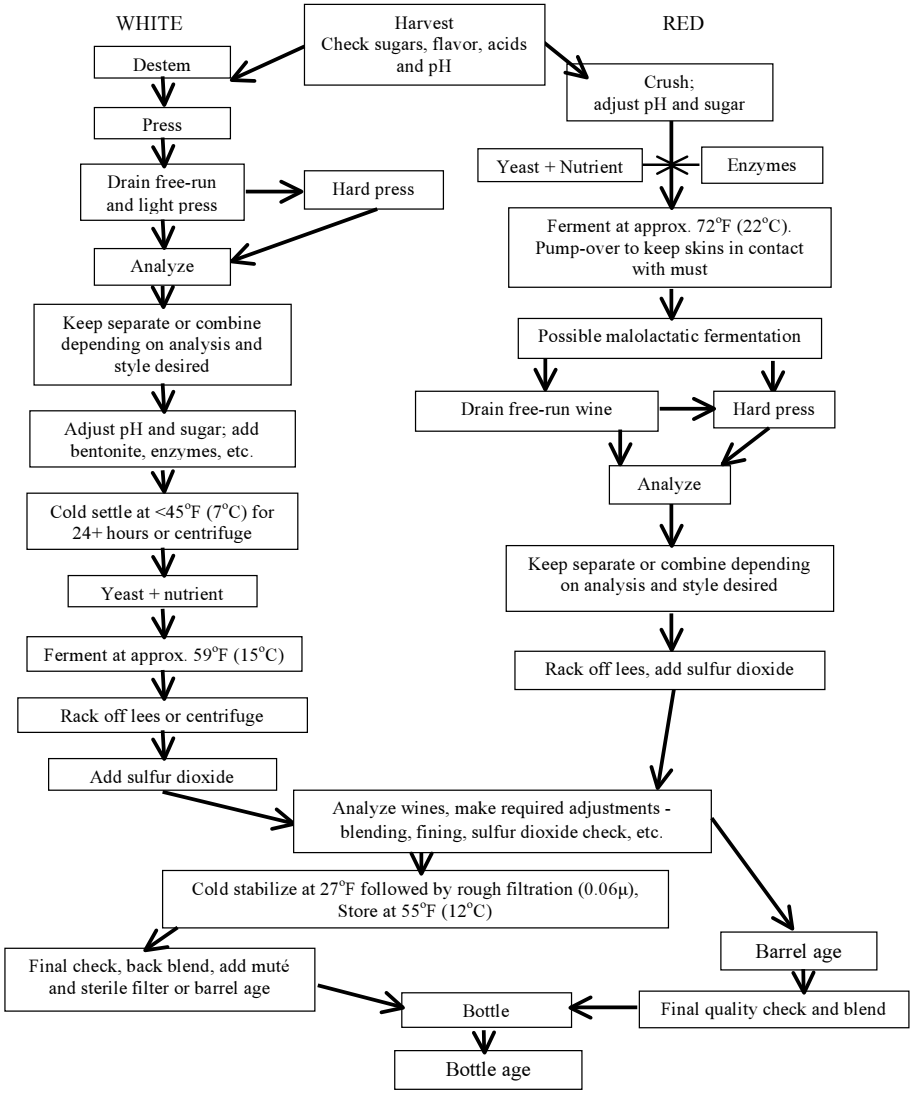


Figure 2. Generic flow charts for processing white and red wine.

Destemming/Crushing

Facilities at the winery for rapid destemming, crushing, and pressing are important in assuring quality wine. Equipment exists that can destem only, destem and crush, or crush first and then destem. The traditional method of mechanical destemming consists of having the crushing rollers located before the destemmer. However, if the stems are crushed, phenolic compounds can be released into the must, so, for some higher quality wines, destemming before crushing is preferred. In most equipment the space between the crushing rollers can be adjusted and some equipment allows the rollers to be removed if crushing is not desired for the wine style. Rubber rollers, available with some equipment, are less likely to damage seeds than steel rollers. The crushing rollers should be designed and spaced to allow for crushing without chopping or flattening the skins, cracking the seeds or breaking an excessive amount of stem tissue.

In white wine production minimum damage to the skins is especially important to prevent the release of phenolic compounds from the skins. Maceration of the skins during crushing may also cause changes in the chemical composition of the juice which can have undesirable effects (Ough, 1991).

Figure 3. Destemming/crushing equipment removes the grapes from their stems and crushes the fruit to release the juice.

If the outer shells of the seeds are broken during crushing, high levels of phenolic materials from the seeds may impart a bitterness or astringency to the wine.

Because crushing/destemming quickly after harvest is vital for good quality wine, consider ease of repair and availability of parts prior to purchas-

ing crushing equipment. Also consider how difficult it will be to load the grapes into the crusher from the picking bins.

Fermentation

Fermentation tanks can be of many different sizes and shapes and may be made of a variety of materials. In most modern wineries, stainless steel has become the material of choice for these tanks because it is durable, easily cleaned, and relatively unreactive to sulfur dioxide (SO_2) and high acid levels. The most favorable temperature for most yeast used in juice fermentation is 70° to 80°F. To stay as close as possible to this optimum, the temperature of the fermenting liquid or pulp should be kept between 75° and 80°F. Since the conversion of sugar to alcohol during fermentation results in the production of heat which causes the temperature of the juice to rise, temperature control is an important consideration for fermentation tanks. Temperature control is especially important for tanks over 50 gallons. Some wineries accomplish this control by placing the tanks in a cold room. However, most modern wineries ferment in stainless steel tanks that are jacketed so that glycol circulation can be used to control the temperature of the tank's contents. Tall tanks should have two jackets, one for the top and one for the lower portion of the tank. This will allow efficient cooling of the tank's contents even if the tank is only half full.

Figure 4. Modern wineries ferment in stainless steel tanks that are jacketed so that glycol circulation can be used to control temperature. (Photo courtesy of Prospero Equipment Corp.)

Many temperature-controlled, stainless-steel tanks are designed so that the tank bottom is sloped and has openings that allow easy removal of pomace. Tanks generally are equipped for automatic pumping of juice over the fermentation cap for red wine production. This pumping-over process is extremely important during primary fermentation when crushed grapes are allowed to ferment on the skins to extract color from the skins of the grapes. After 4 to 5 days of fermentation, the free-run wine or fermented juice is drawn off and the drained solids pressed. The free-run juice/wine and the pressed liquid are combined and pumped to a storage tank for completion of fermentation.

When locating tanks, it is important to leave passages between them for pumps and hoses, room at the top for accessing the fermentation cap, and room underneath to allow draining and easy cleaning under and around the tank. Tanks are sometimes placed outdoors; however, when considering this, it is important to assure that it is not prohibited by local zoning regulations.

Figure 5. A winery needs to have tanks in several sizes to accommodate a variety of operations. (Photo courtesy of Prospero Equipment Corp.)

Pressing

Most modern medium-sized and large wineries use what is known as a bladder press. This consists of a pneumatic batch press that uses compressed air to inflate an internal bag made of thick rubber. The bag crushes the must against an outer perforated, cylindrical stainless steel cage that acts as a sieve. In some presses, the juice or wine is collected through internal draining pipes. The breaking up of the press cake for harder and more complete pressing is accomplished by releasing the pressure on the bladder and rotating the horizontal cage. However, this type of press may be too expensive for many smaller wineries.

Figure 6. Horizontal and vertical presses are available in sizes ranging from the small capacity models shown here to large models capable of handling 20 tons of grapes at a time.

An alternative, economical press for small wineries (5,000 to 10,000 gal) is the vertical Idopress (water-operated bladder press). This press is built like the traditional vertical basket press but has an internal rubber bladder that is inflated to produce the pressing action. The water pressure from a garden hose is adequate to inflate the bladder and press the fruit evenly against the basket. Some small wineries will use two of these units. One unit will be pressing while the other is being emptied and refilled with grapes.

The quality of the pressed wine or juice and the production method or wine style selected is determined by analyses of the various press fractions. Press fractions range from free-run juice, i.e. juice that flows freely from

grapes without the use of external pressure, to hard press juice obtained by applying pressure to the grapes. Generally, hard press juice is high in phenolic compounds and other materials that can have a significant effect on pH, bitterness, and astringency. The winemaker blends the various press fractions to produce wine of the desired style. As a general rule, the highest quality wine is obtained by recombining the free-run juice with juice from the first press cycle.

Settling and/or Centrifuging

Removing the insoluble solids in white juice allows production of fruitier wines and reduces the proteins that cause stability problems. The settling of the insoluble solids can be accomplished either by cold temperature and gravity or by centrifugation. Some wineries use cold temperature settling of juice from white wine grape cultivars prior to fermentation and only centrifuge after fermentation. The centrifuge also can be used after fermentation of red wines. Small wineries may choose to rely on settling because of the cost involved in purchasing a centrifuge.

Following fermentation, the yeast settle rapidly to form compact sediment in the fermentation tank. When the fermentation is completed and the yeast has settled, the fermented liquid should be separated from the yeast sediment (lees) as completely as possible, because this sediment tends to undergo decomposition, potentially resulting in the formation of undesirable flavors. The process of separating liquid from sediment is known as racking.

Fining

Fining is a process of clarification or stabilization whereby a fining agent is added to the juice or wine to coagulate or adsorb and quickly precipitate an undesirable component. Fining agents are used to remove colloidal compounds and proteins that cause cloudiness, to improve wine color, aroma, and/or flavor, and to remove compounds associated with bitterness or astringency. Fining greatly speeds the clarification and stabilization process, making wine production more economical.

Fining agents may be organic compounds such as egg white, casein, isinglass, carrageenan, alginate and activated carbon or may be non-organic compounds like bentonite, copper sulfate, colloidal silica and polyvinylpolypyrrolidone (PVPP Polyclar®). Fining agents are selected based on the mode of action and result desired. They are used at the minimum effective dosage, based on fining trials, as desirable compounds may also be removed from the

wines. The Code of Federal Regulation 27, "24.246 Materials authorized for the treatment of wine and juice" lists the compounds and maximum levels of those compounds that can be used in juice and wine. There is a trend to move away from animal-derived fining agents because of the potential for allergic reactions and potential liability. A warning label is required on the bottle for wines in Australia when egg whites are used as a fining agent. This type of warning label may be required in the United States in the future.

Barrel Aging

During barrel aging, wines undergo a series of subtle yet fundamental changes in color and develop bouquet as the grape aroma of the young wine gradually fades. During this aging, the wine also clarifies and becomes stable.

Figure 7. Aging wine in oak barrels after fermentation is a procedure used by winemakers to alter and improve the wine, particularly red wines.

The wood of the barrel imparts tannins and flavors that add to the complexity and taste of the mature wine. The length of time required for barrel aging depends on the wine, the desired wine style, the wood of the barrel and other factors. Each winemaker has their own procedure or style for barrel aging.

Barrels may be made from various species of white oak. French oak barrels are mainly made from Limousin or Nevers oaks. These tend to impart a "vanilla" character to the wine and are preferred by some premium winemakers. American white oak barrels cost about half as much as French oak barrels and, when used properly, are as acceptable for some wines and styles.

Barrels should be made from wood with uniform grain and should have no insect damage or other defects. Ideally, the wood should be hand-split, air dried, shaped over a wood fire and toasted over an oak fire. For flavor and consistency, the life of a barrel is four to six years. After this the barrel must be rejuvenated by shaving, which extends its life for another four to six years, or replaced. Barrels can usually be shaved once or twice before needing to be replaced.

There are several alternatives to barrels that will impart similar characteristics to the wine. Examples of these include placing sawdust or wood staves inside the tanks. In determining if barrels or some alternative will be used, it is important to weigh the pros and cons of the procedure being considered and to consider the unique management strategies that will be required to obtain the desired results.

Filtering

Proper filtration results in the removal of insoluble solids and removal of microorganisms, assuring a microbiologically stable, bottled product. Considerations in selecting a filter include the pore size of the filter, ease of maintaining sterile conditions, rate of flow, and the total amount of wine that can be put through the cartridge before it must be replaced.

A lees filter, which is used to clean up the lees and tank bottoms, is usually a good investment. It increases wine yields and, depending on the volume of wine produced, may pay for itself quickly. In small wineries, a lees filter can replace, to some extent, the need for cold settling or centrifuging juice by removing the insoluble solids.

Some 5,000-gallon wineries may choose to start out with simple cartridge filters. Even though the housings for these filters are inexpensive, the high cost of the cartridges may make it more practical to use a plate and frame filter. Another method of filtering wines is to use a diatomaceous earth (DE) filter. A skilled operator of a DE filter can rough-filter a wine or can use the filter to accomplish a nearly complete filtration. However, these units require more expertise to use than pad or cartridge filtration systems. Because DE is a crystalline silicate that poses a health threat when breathed, disposal is becoming a problem since it is not allowed in landfills in some states.

Membrane filters consist of two parts—the filter cartridge and the housing in which it is contained. Stainless steel is the material of choice for the filter housing since it is inert and can be easily steam cleaned. However, because stainless steel is expensive, some vintners in small wineries choose to

use plastic, which is less expensive but has the disadvantage of being unable to withstand steam cleaning. Polymers used for filter membranes vary with the manufacturer. All manufacturers sell filter cartridges rated by pore size. Filters rated at 0.65 microns are effective for stopping most yeast. A pore size of 0.45 microns is needed for bacteria.

Filters are sometimes designed to do more than one job. For example, some lees filters can be used to filter finished wine by changing the plate and using a special pump. Note, however, that plate filters cannot be converted to lees filters because of the pressure needed to filter the lees. Some winemaking experts argue against using filters for multiple purposes because they contend the best results come from filters designed for a specific purpose.

Bottling

Bottling is the end process of winemaking. It is an important operation, and many problems with the wine can be prevented by proper bottling. During bottling, it is important to keep out oxygen and microorganisms, especially contamination from the bottling apparatus itself.

Bottles hold the product and protect it during transportation and marketing. This means there are a number of factors that must be considered when choosing bottles. Bottles must work with the winery's filling equipment and fit on retailers' shelves. Wines made from lighter varietal grapes or those that are expected to be on the shelf for an extended period should be in colored bottles that protect them from UV light. In addition to containing and protecting the wine, bottles also convey the image of the wine to consumers. This means the bottle must be attractive, in sizes appropriate for the target consumer, and suggest a quality level consistent with the pricing.

Because new bottles frequently arrive at the winery containing mold, dust, and other particles and bottle supplies maintained at the winery may become dusty, most wineries rinse and clean bottles before use. A few wineries clean their bottles with just a jet of compressed air to remove dust. However, this method is not a very effective cleaning technique and can be used only when glass bottle plants are nearby, when there is a quick turnover in glass inventory, or when glass bottles are stored under clean, low-humidity conditions. Using a bottle washer that includes an SO_2 rinse is a much more effective method of assuring bottle cleanliness. Bottle rinsers should be made entirely of stainless steel so they can be easily cleaned and do not become an additional source of contamination. They must be designed to allow time for the rinse solution to be sprayed into the bottle and then completely drained out before the bottles move into the filler.

Figure 8. Fully automated bottling lines fill and cork the bottles before moving them directly into labeling machines. (Photo courtesy of Prospero Equipment Corp.)

Gravity fillers are the simplest systems. A small 5,000- to 10,000-gallon winery may want to start with a benchtop manual six-spout gravity filler and a hand operated "floor corker." For a 20,000 to 40,000 gallon operation, an eight-spout automatic filler-corker with a nine-spout bottle rinser station and inert gas sparger is recommended. Regardless of size, fillers should be constructed of stainless steel. Automatic fillers should be able to be cleaned in place with steam and the spouts and corking assemblies should be easily disassembled for cleaning. Safety systems to shut off the machine in case of bottle jams are important to avoid bottle breakage and product loss. Descriptions of numerous modern bottling and corking machines are available from their respective manufacturers.

In selecting packaging equipment, it is important to consider all products that may be run through the line. Many wineries are finding that markets are developing for other products like juice, sparkling wines, carbonated nonalcoholic fruit drinks and ciders. Adaptability of bottling equipment to handle these products will allow the winery to extend product lines and increase profitability.

Capsuler

A capsule, or thin cap, is often placed over the top of the bottle to protect the closure, improve the appearance of the wine bottle, and maintain the image of quality. Modern wineries use capsules made from materials like tin/aluminum, heavy duty plastic and heat-shrink plastic.

One of the major differences in capsule types is their cost. Tin capsules are the most expensive and are often used on premium or reserve wines. Heavy duty plastic capsules are moderately priced while the heat-shrink plastic units are the least expensive.

Figure 9. Capsules may be used to protect the closure and enhance the bottle's appearance.

Most small wineries (5,000 to 8,000 gallon) apply capsules by hand using a single motorized, bench-mounted, hand-fed spinner. Capsules also can be applied automatically. An automatic capsule distributor should be installed when labor for hand application becomes too expensive. This usually occurs in wineries producing 20,000 gallons and more. Automatic distribution machines can hold up to 1,500 capsules in stacks in a magazine. As each bottle passes underneath, a photoelectric cell detects the bottle, checks for a closure and then drops a capsule over the neck. Speeds of 1,000 to 6,000 bottles per hour are possible.

Heat shrink capsules require a heat treatment to secure them to the bottle tops. Smaller wineries often start with a semi-automatic oven to shrink capsules. On automatic lines a simple radiant-heat tunnel applies heat to the capsule. On faster lines narrow jets of hot air are directed at bottle tops to shrink the capsules.

Labeling

In an effort to save on capital investment, most small wineries label by hand in a separate operation that follows bottling. However, when considering the economics of applying labels, it is important to remember that hand labeling leads to added labor costs. Small wineries (5,000 to 10,000 gallon) can either totally label by hand or can use a semi-automatic labeling machine. After a winery reaches the 20,000-gallon capacity, automation of labeling becomes more practical.

Many options for labeling machines are available. An automatic, in-line, pressure-sensitive labeling machine with an automatic capsule distributor and foil spinner or a heat-shrink oven is one choice. A linear labeling machine for full-width, wet-glue wrap-around labels, or a rotary labeling machine with full-width glue application for a front, back, and shoulder label are other options. These machines have the capacity of labeling from 2,000 to 3,000 bottles per hour.

Today a majority of wineries are choosing to use pressure-sensitive labels. The major advantages of these labels are simplicity of operating the machines that apply them, the lack of messy glue, and ease in switching among labels of differing sizes.

Other Wine Handling Equipment

When the speed of a small bottling line reaches about 50 bottles per minute, an accumulator table should be provided at the end of the bottling line before labeling. This insures bottling will not be held up if labeling does not keep pace with the bottling operation. The end of the line also should have an unscrambling table.

Pumps are necessary in the winery to move the wine from one operation to another. There many different types and sizes of pumps available and a winery may need several pumps depending on the type of operation, the volume of liquid to be moved, and the operating requirements of the facility.

Winery Establishment Costs

Prepared by Mike Thomsen

The costs of establishing wineries ranging from 5,000 to 20,000 gallons of annual fermentation capacity are summarized in Table 1. Building sizes and equipment lists used in the establishment budgets are representative of actual wineries and are based on input the authors received from winemakers and equipment vendors. Itemized equipment lists are presented in Appendix E and, unless otherwise noted, the equipment costs reflect prices for new equipment. Due to substantial variability in land values from one location to the next, the cost of land is excluded from the reported expenses. Also not included are the costs for cleaning and sanitation equipment since this will vary with the system used. Thus, in developing your own winery budget, it would be appropriate to adjust the total costs of establishment upwards to reflect land or other costs that are specific to your location or unique to your situation.

As shown in Table 1, the building and equipment costs for a small winery range from $200,789 for a 5,000 gallon winery to $781,078 for a 20,000 gallon winery. This suggests costs in the neighborhood of $39 to $40 per gallon of capacity with equipment accounting for 40 to 46 percent of the total, depending on the size of the winery.

After the winery building, fermentation and storage equipment are the largest expense category (Appendix E, Table 2) and, regardless of winery size, represent over half of all equipment costs. This reflects, in part, recent and substantial price increases for both American and French Oak cooperage.

The budgets indicate that economies of size are relatively unimportant over the 5,000 to 20,000 gallon capacity ranges considered here. In other words, the ability of a larger winery to spread equipment costs over more volume, and thereby lower per-gallon investment costs, is largely offset by the need to adopt more expensive, industrial-scale equipment. Particularly dramatic illustrations of this can be found in the over threefold increase in the costs of receiving and crushing equipment as one moves from a 10,000 gallon to 20,000 gallon winery (Appendix E, Table 1), and the more than fivefold increase in costs of cellar equipment as one moves from a 5,000 gallon winery to a 10,000 gallon winery (Appendix E, Table 3).

This lack of scale economies has implications for the business model of small wineries. First, it suggests that capacity should be chosen so as to optimize the average revenue per bottle sold. Because of the relatively con-

stant investment cost per gallon, a winery that can move all of its wine through high-margin tasting room sales will have a better return on investment when compared to a winery that is required to move some of its product through lower margin wholesale customers. In short, the capacity of the small winery should correspond to the amount that can be sold at the highest markup. Second, to the extent that small wineries expand beyond what can be sold through their highest margin outlets, the budgets suggest it is necessary to grow beyond the 20,000 gallon level to some point where economies of scale do become important and the average investment costs per gallon decline as output increases. Earlier work at the University of Arkansas has suggested that there is not a significant cost-per-gallon decline until wineries exceed 40,000 gallons of annual fermentation capacity, suggesting smaller wineries should be designed so they can accommodate expansion.

Table 1. Establishment expense summary for small wineries[1]

	Plant size (annual fermenting capacity in thousand gallons)		
Expense Items	5	10	20
Receiving and Crushing	$11,639	$24,174	$76,828
Fermentation and Storage	$57,060	$103,780	$196,930
Cellar	$7,970	$43,810	$50,700
Bottling Line	$4,120	$13,095	$36,620
Total Equipment	$80,789	$184,859	$361,078
Building sq. ft.	2,400	4,400	8,400
cost	$120,000	$220,000	$420,000
Total Costs (excludes land)	$200,789	$404,859	$781,078
Equipment costs per gallon of capacity	$16.16	$18.49	$18.05
Total costs per gallon of capacity	$40.16	$40.49	$39.05

[1] Data compiled by Mike Thomsen, Department of Agricultural Economics, University of Arkansas, Division of Agriculture; Justin Morris, Viticulture and Enology Program, University of Arkansas, Division of Agriculture; and Andrew Post, Post Winery, Altus, Ark.

Equipping the Winery Laboratory

The laboratory is the heart of the winery. A good laboratory is needed if quality control is to be maintained. This is where the winemaker gathers information, formulates decisions, directs responsibilities, and records winery activities and data. It is not uncommon for the winemaker in a small winery to become the liaison between the winery and the TTB. Assuring compliance with state and local regulations that are applicable to the small winery also is handled by the winemaker (Vine et al., 1997).

Table 2 lists the equipment recommended for inclusion in a winery laboratory. Although the list may look overwhelming, new winery operators should consider that this list is a recommendation only and can be modified. Some of the items on this list are basic laboratory supplies and are relatively inexpensive to purchase. Some of the other items are for specialized analyses. Many of the items on the list can be found in versions ranging from relatively inexpensive to extremely high-priced. In selecting the equipment to purchase for a laboratory, it is important to consider what information will be needed and what grape and wine components must be evaluated to obtain this information. In many cases the less expensive, more basic versions of an instrument will provide sufficient information to meet the needs of the winery.

In general, there is no single test that is "best" for measuring a particular grape or wine component. Factors that must be considered in selecting tests to be performed include ease of conducting the test, accuracy and sensitivity of the test, speed, and cost. Since some laboratory instruments can cost more than those with limited budgets can afford, a small winery may want to begin with just the basic equipment needed for traditional and required analyses. In some situations, a winery owner may find it costs less to pay an outside laboratory for complicated analyses than to purchase the equipment and train personnel to do the tests in their own laboratory. This option does result in added time to get the tests done. This delay must be weighed against the cost savings when deciding how the tests will be done.

A number of excellent resources address the topics of equipping and operating a winery laboratory. Carey (2003) provided a comprehensive discussion of equipping a winery laboratory in a series of articles started in the 2003 Wine East Buyers' Guide. The books "Wine Analysis and Production" by Zoecklein et al. (1995) and "Chemical Analysis of Grapes and Wine: Techniques and Concepts" by Iland et al. (2004) have become industry standards for procedures for wine analyses. Complete citations for these materials can be found in the reference section at the end of this publication.

Table 2. Traditional wine and grape laboratory equipment. (Adapted from: Carey, R. 2003. Essential wine and grape analysis. Wine East Buyers' Guide. p. 6)

Cash/Markham Still	pH Meter
Paper Chromatography Equipment	Ripper Equipment
Ebulliometer	Refractometer
Filtration Equipment	Scales
Forceps and other Manipulators	Spectrophotometer
Heat Source	Test Kit for Residual Sugar
Hydrometers	Titration Equipment
Material Mixing Equipment	Assorted Chemicals and Reagents
Microscope	
Miscellaneous Glassware including beakers/flasks, sample containers, test tubes and racks, and pipettes	

While many of the items listed in Table 2 are common to all laboratories and therefore familiar to anyone who has taken a basic chemistry course, some of the items may be less familiar or have unique uses for grape and wine analysis. These are discussed briefly below.

- An **ebulliometer** is used for testing alcohol content of the wine. An ebulliometer works by determining the difference in the boiling point of the wine and that of pure water. Since this difference is related to the alcohol content of the wine, tables that come with the instrument can relate the boiling point information obtained to alcohol content of the wine.

Figure 10. An ebulliometer is used for testing alcohol content of wine. This test is important not only for determination of wine composition but also for tax determinations that are based on alcohol level.

- **Titration** is the easiest and least expensive method to determine titratable acidity, a measure of wine tartness and nitrogen content (measured in juice to determine nutrient addition needed). For simple titration a laboratory should have a burette, burette stand, glassware, reagents (chemicals) and a pH meter (see below). More elaborate setups which automate some of the steps are available but are more expensive than the basic set-up.
- A **pH meter** is an essential piece of equipment for a winery laboratory. This meter is used to measure pH of both the juice and the finished wine. Since pH affects wine characteristics such as color, flavor, aroma, clarity and stability, this is an important test. The pH scale ranges from 0 to 14. As acidity increases, the numbers get lower and as alkalinity increases, numbers go up. A pH of 7 is considered neutral, neither acid nor alkaline. Although pH can be measured using litmus paper, which is less expensive than a pH meter, measurements made with these papers are not precise enough for use in a winery. pH meters come in a variety of models, from simple handheld units to elaborate benchtop types. The cost for these units varies considerably depending on features such as temperature compensation, number of calibration points, and capability to measure on scales other than pH. The most important consideration in selecting the model for a laboratory is to get one that provides accurate measurements, that is suitable for the conditions in the lab, and to select a rugged pH probe. pH probes have to be replaced at four-to-six month intervals so ready availability of probes also is a consideration.

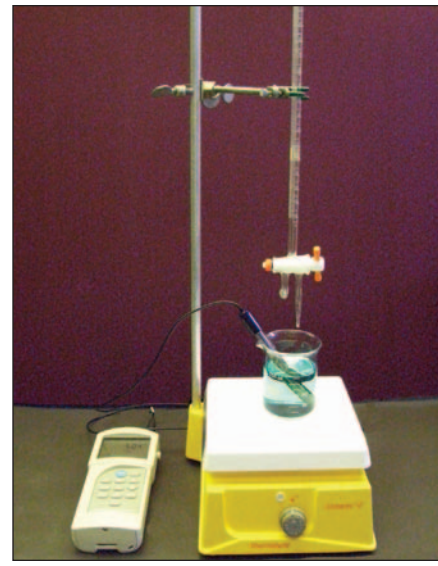


Figure 11. Because of the affect of acidity on wine quality, a good pH meter is a necessary piece of equipment in a winery's laboratory.

- **Hydrometers** are simple, relatively inexpensive instruments used to determine specific gravity, which can be related to the sugar content of juice and wine. Hydrometers can be obtained with a variety of different scales. Some are calibrated for specific gravity, others for potential alcohol, percent sugar, or degrees Brix.

Hydrometers consist of closed glass tubes that are weighted at one end. When placed in a liquid, they float at different depths, depending on the amount of material dissolved in that liquid. A scale on the tube is used to relate the depth at which the instrument floats to the sugar concentration of the liquid. The higher the sugar content in juice or wine the higher the hydrometer floats.

Figure 12. In order to use hydrometers, a sample of juice or wine is placed in a glass cylinder (usually a laboratory graduated cylinder). When the hydrometer is placed in the sample, it will float indicating the amount of material dissolved in the liquid sample.

Hydrometers are calibrated to measure within specific ranges. A set of four hydrometers with the Brix ranges of -5.0° to +5.0°, 0.0° to 8.0°, 8.0° to 16.0°, and 16.0° to 24.0° is recommended for a winery laboratory.

- **Refractometers** provide a quicker, more convenient way of measuring sugar content of grapes and juice. These devices work on the principle that material dissolved in a liquid will cause light that is passed through that liquid to be bent. Measurement of this bending gives an indication of how much dissolved material is present. Refractometers are available in a variety of models from small hand-held versions that can easily go to the vineyard to test grape ripeness to larger tabletop models that give extremely precise measurements. Although refractometers are more expensive than hydrometers, they offer advantages in that they can test very small amounts of juice, such as the juice from a single grape, and tests can be done with little sample

preparation. A well-equipped winery laboratory will have both a refractometer and a set of hydrometers since refractometers are not useful once fermentation has started.

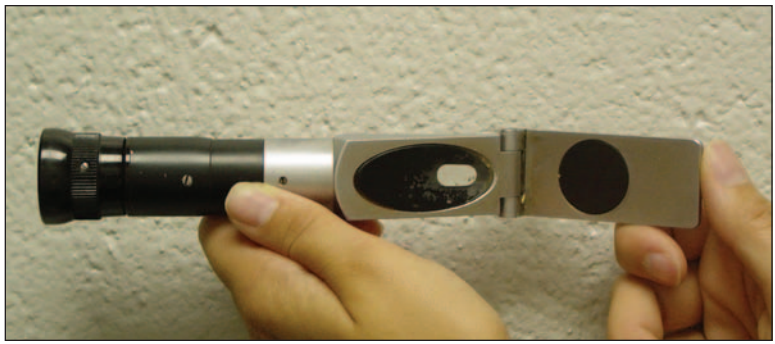


Figure 13. A handheld refractometer can be used in the vineyard as well as in the laboratory to determine sugar content of fruit and juice.

- The **Ripper analysis**, which involves an iodine titration, is one of the most common methods used for SO_2 analysis. The equipment for this test is basically that used for titration and is relatively inexpensive. There are some complications in using the test, however, since the test must be done with chemicals that are accurately standardized. Since the iodine solution used is not stable, it must be standardized regularly. An additional problem in using the test is that it is sometimes difficult to determine the endpoint of the titration when testing red wines. These problems can be overcome with sound laboratory procedures so that the test is generally accurate enough for winery laboratories.

  Titret® test kits (Chemetrics, Calverton, Va. – www.chemetrics.com) offer an alternative to the Ripper procedure. These kits consist of glass ampoules that contain the same chemicals used in the Ripper analysis. To perform an analysis, the tip of the

Figure 14. Test kits are often used to determine SO_2 in wine. The kit consists of ampoules containing the test chemicals. When the vacuum in the ampoule draws in the wine it mixes with the chemicals to provide a measure of SO_2.

ampoule is broken and a small valve allows wine to be drawn into the ampoule. A color change indicates when enough wine has been added to complete the reaction. The amount of SO_2 is read directly off of a scale on the ampoule. Although these kits are somewhat inaccurate, they provide basic information at a fairly low cost and require little time or specialized equipment.

- **Tests for residual sugar** determine when fermentation is complete or when fermentation should be stopped if residual sugar is desired. Since sugar remaining in wine after bottling can lead to a secondary fermentation, it is important to know that no residual sugar is present. If residual sugar is present, sterile filtration must be used. Due to the interference of alcohol, residual sugars can not be measured with hydrometers or refractometers so most labs test for them using residual sugar test kits. Accuvin (www.accuvin.com) produces test kits for residual sugars as well as kits for several other important wine tests.
- A **Cash/Markham Still** is used for volatile acid analysis. Volatile acids are acids that turn to vapor when heated. Wine normally contains some volatile acid, usually acetic acid, as a result of fermentation. In addition, spoilage organisms may cause an increased presence of volatile acids. Measuring the amount of volatile acidity in wine is useful for the detection of spoilage and to assure compliance with federal regulations regarding allowable volatile acidity levels. Carey (2003) suggests that, while volatile acidity is an important flaw in wine, this specialized, somewhat expensive piece of equipment is probably not necessary if other laboratory tests are done properly and at the appropriate times.

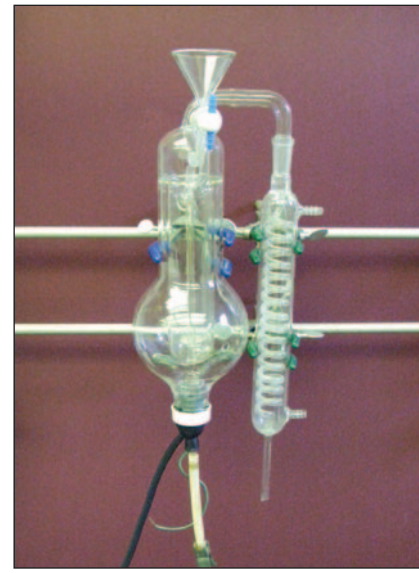


Figure 15. A Cash Still can be used to determine the level of volatile acids in wine.

- A **Spectrophotometer** takes a light source and splits it into its component wavelengths. By selecting a narrow band of wavelengths and passing them through a solution, it is possible to measure the percentage of light at that

wavelength that is absorbed by the solution. This provides information on the presence of components in the solution. Spectrophotometers are available in models ranging from very simple units that test one sample at a time at a designated wavelength to complex units that automatically feed in multiple samples, test at multiple wavelengths, and feed the results directly into a computer for analysis. Choosing the best model is a matter of considering the information needed, the time needed to get this information with the various instruments and the money available for buying equipment.

Figure 16. Spectrophotometric analysis is useful for determining turbidity (cloudiness) and ripeness of tannins in wine and juice.

Recordkeeping

Successfully operating a winery requires that records be kept for all aspects of operation. Each phase of the winemaking process should be documented both to verify that appropriate practices were followed and as a means of duplicating the process in the future. All laboratory tests should be documented. Records of expenses for winery operation and wine production and for prices received will be required to determine profits or losses of the operation. Records will need to be kept on each employee that cover such details such as hours worked, wages received, and taxes and benefits paid.

Extensive recordkeeping is required by TTB. Documentation must be maintained for everything from materials received and used through production issues and amount of wine bottled, stored and shipped. Inventory records must be maintained for wine in bond, wine removed from bond, and taxpaid wines. Records also should be kept to verify taxes that are paid. In addition to TTB requirements for what records must be kept, there are rules for when

information should be recorded and how long records must be maintained. In order to assure all of the requirements are met, it is important to begin working with TTB early in the planning stages for starting the winery.

It is easy to see that operating a winery is not for those who are not willing to commit to maintaining the required paperwork. There are a number of computer programs available to assist in this chore. These range from simple spreadsheets to elaborate programs specifically designed for use by wineries. The costs for obtaining recordkeeping software can also range from relatively little to quite high. Many entrepreneurs find they do best to start with a simple recordkeeping system and allow it to grow with the business.

Sanitation and Waste Management

Prepared by Pamela Brady

Regardless of the size of the winery, producing and maintaining high quality wine require sound sanitation and waste-management programs. Although making wine involves the action of microorganisms, controlling which organisms are present and their levels throughout processing, filling and packaging is essential. In addition, by its very nature, the winemaking process results in the production of a lot of waste material which, if not handled properly, can become a problem due to quantity, aesthetics, and environmental issues.

Reliable sanitation and waste-management programs maximize shelf-life and quality of the product; extend the life of processing equipment; enhance employee productivity, efficiency and morale; and help assure regulatory compliance. In Arkansas, as in many other states, a large percentage of a winery's business is from tourists. The environment in and around the winery is important to provide these visitors with an atmosphere that will encourage purchases and return visits.

As is often stated, it is much easier to construct a winery that is easy to clean and sanitize than to correct problems that develop from poor winery design. Once the winery is operational, establishing a sanitation program will involve assessing the operation, designing a sound program for cleaning and sanitizing, and constantly monitoring the program to assure it is working.

The first step in a sanitation program should be thorough cleaning. This helps to remove soil and control the number of microorganisms present. Water alone, especially hot water, works well as a cleaner since it removes most of the soil found in winery operations. Cleaning must be followed by a

water rinse. At this point the surfaces will appear clean; however, many potential spoilage organisms can still be present. Therefore, a sanitizing step to reduce the microbial contaminants to safe levels is the final step. Sanitizing can be accomplished in a number of ways; however, one of the most popular is the use of heat, applied in the form of steam, hot water, or hot air.

Drinking-quality water should be used for all cleaning and sanitizing activities. If the supply of good quality water is limited, it might be possible to do rough cleaning, such as initial soil removal, with lower quality water then use higher quality water or other treatments for finer cleaning and sanitation steps. Depending on the quality of the water and the treatments it receives, it is sometimes possible to recycle water so that water that was initially used in the later steps of sanitation is re-used for initial cleaning steps.

Although water requirements vary with the winemaking plan, on the average it takes 10 liters of water to produce 1 liter of wine. Waste water generated by wineries, especially during the crush, is considered "high strength," i.e. high in Biological Oxygen Demand (BOD), because of the sugar content inherent in the winemaking process. Reducing the BOD efficiently and inexpensively is the ultimate goal of waste water treatment. Winery waste water-treatment systems should include course and fine screens to remove suspended solids, waste matter treatment, pre- and post-treatment monitoring, adequate storage and appropriate disposal. If the winery is located in a vineyard, treated wastewater can often be recycled for irrigation. Because of the volume of effluent, special permission may be required before using municipal sewage systems for winery waste water disposal.

Steam has become especially popular for cleaning and sanitizing wineries since it evaporates as it is used. This greatly reduces the amount of water for disposal. Many winemakers now use steam to clean and hydrate barrels, clean and sanitize tanks, clean equipment and walls, and sterilize bottling lines. Advantages of steam for these functions include that its 212°F temperature effectively kills almost all juice and wine microorganisms, it leaves no residues, and it is non-corrosive and relatively inexpensive. Major disadvantages of steam as a sanitizer are that the generators to produce it require a lot of power and, when steam is not handled properly, it can be hazardous to workers.

Wineries also produce a great deal of solid waste in the form of pomace, the skins and seeds remaining after the grapes are crushed. Some wineries dispose of this material by composting it then using the compost on their own land or selling it to local landscapers. Unfortunately, in many locations,

the market for this material is limited and wineries have to find other methods of pomace disposal.

The final part of good sanitation and waste-management programs is proper monitoring and reporting. Visual inspection to assure adequate cleaning is an important component of assessment. Microbial testing may be used to verify that sanitation efforts are having the desired results. Records should be kept for all activities and test results recorded to document program activities and to verify compliance with environmental protection rules and regulations.

Chapters 9 and 10 in "Principles of Food Sanitation" by Marriott and Gravani (2006) provide a detailed discussion of cleaning and sanitizing compounds and considerations in their selection. Applications of the various materials in a winery sanitation program are discussed in Chapter 20.

HACCP

The Hazard Analysis Critical Control Point (HACCP) system is a scientific process used to identify significant hazards in a product. Steps for the control of these hazards during product processing and handling also are identified. Critical limits are identified for each process step along with procedures for corrective action if these limits are exceeded. Because there have been several outbreaks of foodborne illness associated with fruit juices, federal regulations have been developed that require juice processors to develop and implement a HACCP plan. Guidance for establishing a juice HACCP program can be found on the FDA Web site:
http://www.cfsan.fda.gov/~dms/juicgu10.html

Figure 17. Federal regulations require juice processors to develop and implement a HACCP plan.

The requirements for using HACCP when making juice do not apply to juice that will be used as the starting material for a fermented alcoholic product if the original juice becomes modified to the extent that it becomes an alcoholic beverage and is no longer recognizable as juice when the processing is complete. However, if unfermented juice is added to an alcoholic beverage as an ingredient to adjust flavor or sweetness and if the juice retains its flavor, color, and nutritional value in the finished beverage, then it must be prepared using a HACCP system.

Although not required by law, a HACCP-type system is useful in the vineyard and winery since it provides a decision-tree approach to decision making that can help avoid mistakes.

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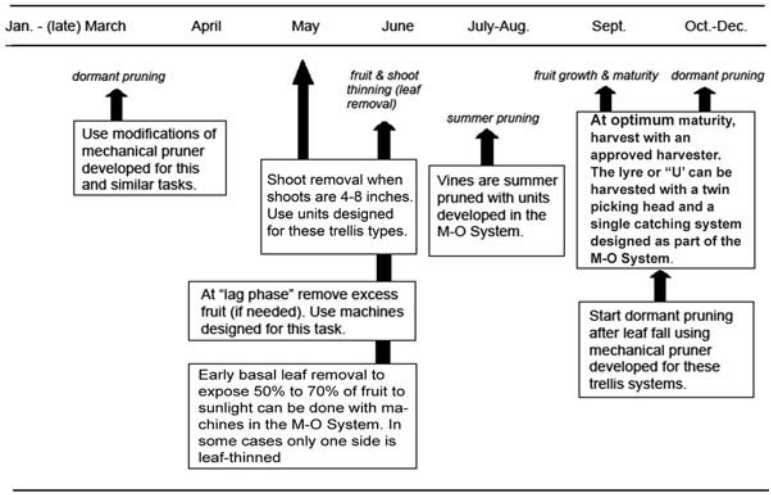
Appendix A
Viticulture and Enology Research at the University of Arkansas

Enhancing the productivity and profitability of the wine and juice industry in Arkansas and the region has been the focus of research in the Viticulture and Enology Program of the University of Arkansas Division of Agriculture's Institute of Food Science and Engineering and Food Science Department. To date, this research has resulted in over 350 presentations and publications in books, scientific journals, and wine industry magazines. A brief description of this work follows. Also included is a list of the publications and presentations with results most directly affecting the wine and juice industry. A more complete publication list along with links to many of the publications can be found at the UA Viticulture and Enology Web site: http://www.uark.edu/depts/ifse/grapeprog/default.html

Viticultural studies have included investigations of wine grape varieties and their suitability for growing in the state and region. Vineyard research has optimized grape yield and quality based on factors such as pruning severity, training systems, and shoot positioning. Other studies have looked at the effects of the pre-harvest complex on such factors as wine quality, yield, maturity rates, pH, acidity, and soluble solids.

Research to improve vineyard profitability by reducing dependence on hand labor resulted in the development of the Morris-Oldridge Total Vineyard Mechanization System (M-O System). This System, patented in 2002, defines the equipment, procedures, and sequencing to mechanize the vineyard operations for the 12 major trellising systems used throughout the world. An example of the sequence of steps and timing of operations for one of these trellising systems is shown in Figure A-1. Similar sequencing was developed for each of the trellis systems.

Development of the M-O System also included development or adaptation of over 40 different machines or attachments. Once the plan was completed and the equipment developed, studies were initiated to assess the effectiveness of mechanization in commercial vineyards. Using all or part of this mechanization system has been shown to produce grapes comparable in quality to those produced using hand labor (Table A-1) and wine comparable to that made from hand-farmed grapes (Table A-1) while reducing production costs (Table A-2).



[z]Designed for viticultural regions in the United States. Appropriate timing would be modified for the southern hemisphere and other viticultural regions.

Figure A-1. Steps and timing of operations in the Korvan™ Vineyard System (M-O System) for *Vitis vinifera* on Lyre or "U" trellises.[z]

Table A-1. Grape composition, final berry weight, and sensory scores for wines from six cultivars grown with either hand- or machine-farming (2003-2005).

Cultivar	Farming method	Final berry wt (g)	pH	°Brix	Titratable acidity (g/L)[a]	Wine Sensory Score (Scale 1-20)
Chardonnay[b]	Hand	1.02a[d]	3.65a	23.0a	8.6a	15.0a
	Machine	1.03a	3.56a	23.1a	8.4a	15.4a
Sauv blanc[b]	Hand	1.09a	3.71a	22.7a	6.0a	14.2a
	Machine	1.04a	3.64a	22.8a	5.9a	15.2a
Merlot[c]	Hand	0.92a	3.53a	24.3a	7.8a	14.8a
	Machine	0.91a	3.53a	24.7a	8.2a	14.0a
Sangiovese[c]	Hand	1.22a	3.68a	25.1a	6.8a	13.0a
	Machine	1.14a	3.56a	26.7a	6.7a	13.0a
Syrah[b]	Hand	0.93a	3.68a	25.4a	8.0a	13.4a
	Machine	0.83a	3.64a	24.5a	7.8a	14.0a
Zinfandel[c]	Hand	1.27a	3.49a	24.6a	8.4a	12.2a
	Machine	1.18a	3.50a	24.3a	8.0a	11.2a

[a]Titratable acidity as tartaric acid
[b]Trellised on Lyre= Chardonnay, Sauvignon blanc, Syrah
[c]Trellised on VSP=Merlot, Sangiovese, Zinfandel
[d]Means within a column and cultivar followed by the same letter are not significantly different by the Tukey test ($p \leq 0.05$)

Table A-2. Comparison of costs for pruning, shoot thinning and fruit thinning by hand or machine farming on three trellis systems during the 2005 season.*

Machine farm	VSP[a] ($/acre)	Lyre[b] ($/acre)	Quad[c] ($/acre)
Prune	119.84	239.67	157.28
Follow-up	67.35	72.08	47.36
Shoot thin	78.03	156.07	117.05
Fruit thin	78.46	78.46	58.84
TOTAL	343.68	546.28	380.53
Hand farm			
Pre-prune	26.93	53.86	37.87
Prune	251.04	386.92	317.76
Shoot thin	232.00	463.99	463.99
Fruit thin	109.16	175.87	175.87
TOTAL	619.13	1080.64	995.49
DIFFERENCE (Hand - machine)	275.45	534.36	614.96

[a]Vertical Shoot Positioned Trellis
[b]2-ft Lyre Trellis
[c]3-ft Quadrilateral Trellis
*Dr. Mike Thomsen, Dept. of Agri. Econ., University of Arkansas, Fayetteville, and Hank Ashby and Drew Piazza of French Camp Vineyards are acknowledged for their efforts in collecting these data.

Winemaking is an important industry in Arkansas. This industry's ability to produce quality wines has been enhanced by research in the Viticulture and Enology Program. Enology research has included several studies focused on preventing oxidation and browning in white wines and juices. This research looked at the effectiveness of ultrafiltration and chemical agents such as ascorbic acid and bentonite for reducing browning. Investigations of different methods to reduce the use of sulfur dioxide have been conducted. Further research efforts have been directed toward enhancing the storage and oxidative stability of sparkling wines and wine coolers, modification of wine styles using a thin film evaporator, and determinations of the effects of using grape juice concentrate to produce high-alcohol wines. Additional topics of interest to winemakers which have been researched include determination of the levels of anthocyanins, volatile terpenes, and resveratrol in various types of wines and the assessment of the functionality of yeast isolates in wine production.

Expanding markets or identifying new markets for table and juice grapes is of particular interest to the grape industry in Arkansas. Work in the UA Enology and Viticulture Program to address this interest has included:

- A study of the acceptability of blueberry and cranberry juices blended with Venus and Concord grape juices.
- An analysis of the economic benefits of producing juices in small- to medium-sized wineries
- A study of the effects of several preharvest factors on yield and quality of Niagara, a popular juice grape variety.
- Identification of table and wine grapes suitable for use as grape juice.
- Development of processing methods for wine grape juice. Other processing studies looked at the use of antimicrobial agents and yeast growth regulators in Venus and Concord grape juices.
- The juice grape cultivar named 'Sunbelt' which is similar to Concord but can thrive and produce high quality juice in the hot, humid summers of the South was released by Drs. J.N. Moore, J.R. Morris and J.R. Clark. Recent studies have shown 'Sunbelt' to be highly productive in the San Joaquin Valley of California.

The Viticulture and Enology Program has done extensive research with muscadines, grapes native to Arkansas and the southeastern region of the U.S. These grapes have tremendous undeveloped market potential as fresh fruit, in processed products, and for the production of nutraceuticals. Research has been underway for a number of years to identify the muscadine cultivars most suitable for commercial production in Arkansas. Studies also have been conducted to determine the best methods to handle the fruit to assure a quality product in the fresh markets. Product development studies have been directed toward determining formulation and production procedures for value-added products from muscadines. Because approximately 40% of the muscadine fruit is skin or seed, typically considered waste product, studies have been undertaken to identify ways to reduce these waste materials or to find use for them.

Research into the viticultural and enological aspects of grape and wine production in the state and region is vital to help assure the health and growth of the industry. However, equally important is a thorough understanding of the economics of grape and wine production. Researchers within the Department of Agricultural Economics have been important partners with those in the Viticulture and Enology Program to study factors such as pricing strategies and operation costs. Production budgets have been developed to assist vineyard and winery operators in planning. Economic effects on winery operations due to winery expansion, changes in product mixes, expansion of winery operations into juice grape markets, and shifts in consumer attitudes also have been studied.

The economic effects of trends such as the effects of yearly grape supply and wine production fluctuations, and the use of red wines to address the French Paradox have been studied and are reflected in the start-up budgets for new wineries developed by Viticulture and Enology Program researchers.

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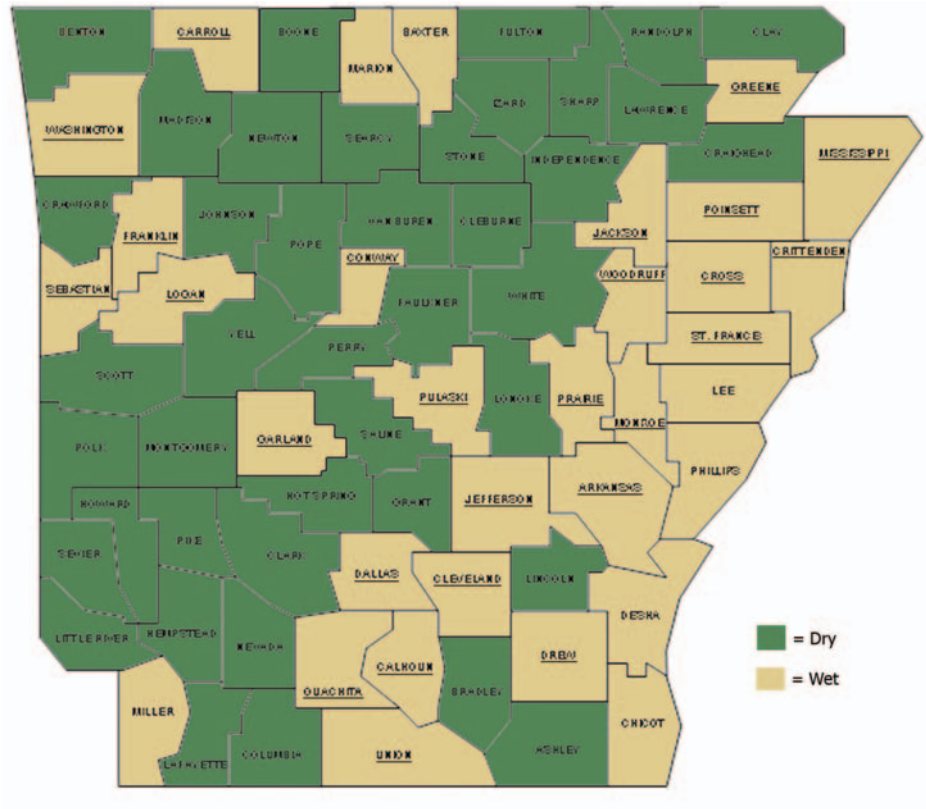
Appendix B
Dry and Wet Counties in Arkansas

Note: Most of the wet counties have dry areas within their borders. These counties are designated on the map by underlining the county name; designations vary with county election outcomes. The Regulations of the Arkansas Alcoholic Beverage Control Board include a list of these exceptions. These regulations may be found on the Internet at http://www.arkansas.gov/dfa/abc_administration/documents/abc_regs.pdf



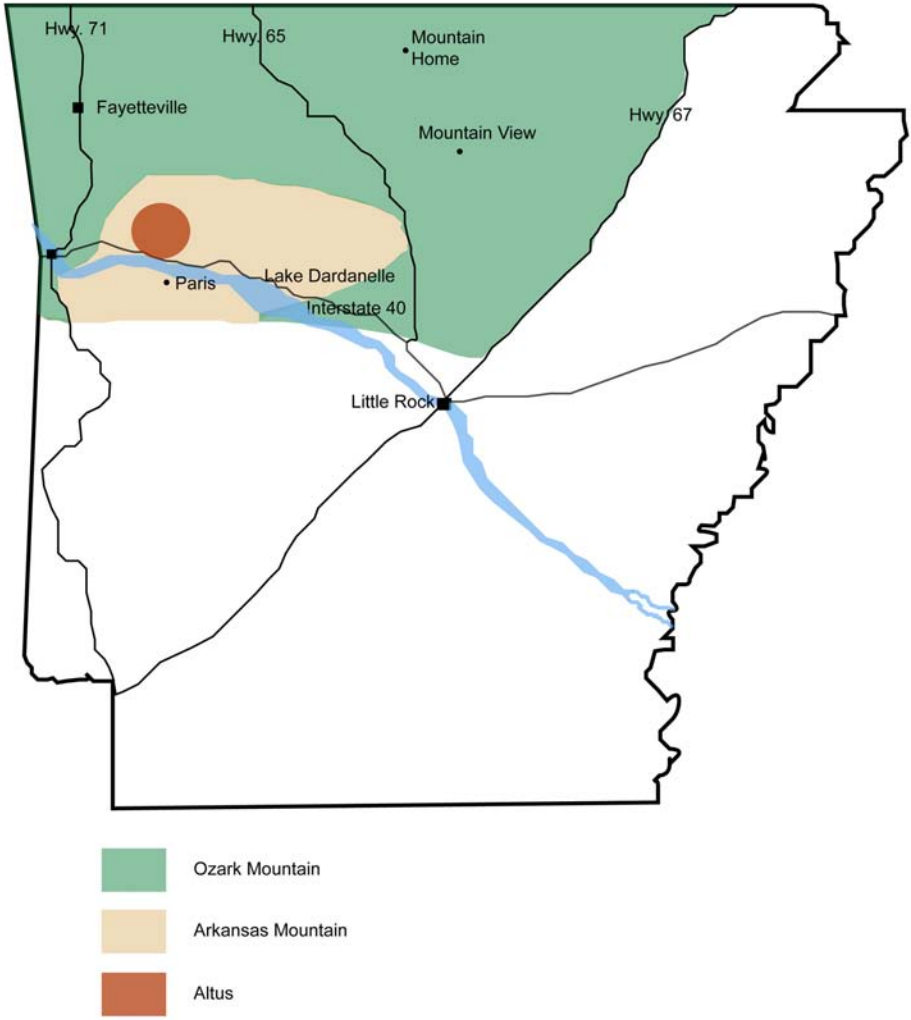
Appendix C
American Viticultural Areas – Arkansas

TTB regulations (27 CFR part 9) allow the establishment of American viticultural areas (AVAs) and the use of their names as appellations of origin on wine labels and in wine advertisements. A viticultural area for American wine is defined as a grape-growing region, distinguishable by geographical features, which has been recognized and defined according to the regulations. Because the climate, soil, elevation and similar properties within an AVA are the same, the wines produced from grapes grown in that area have certain characteristics. Thus, designation of a viticultural area on the label allows winemakers and consumers to attribute given quality, reputation, or other characteristic to a wine made from grapes grown in this area. In order to be designated as being from a specific AVA, not less than 85% of the volume of the wine must be derived from grapes grown in the labeled viticultural area, the wine must be fully finished in the state where the viticultural area is located, and production of the wine must conform to all laws and regulations of the state in which the area is located.

The list of designated AVAs is growing as more regions are submitted to TTB for this designation. An up-to-date list of areas that have been assigned this designation can be found at
http://www.ttb.gov/appellation/us_by_ava.pdf

Arkansas has three regions designated as American Viticultural Areas. These are indicated on the map on the following page.

American Viticultural Areas in Arkansas



Appendix D
Wine Label Information

TTB regulations are very specific and spell out in detail the information that is presented on a wine label. The discussion on the following page is an overview of the key label elements. For in-depth information about labeling wine products, please see the labeling section of the TTB Web site (http://www.ttb.gov/labeling/index.shtml)

(Note: Orange boxes are solely to identify elements for this discussion and are not part of the label information.)

1. **Brand** – The name used by the bottler to identify the product. Any brand name is acceptable so long as it does not mislead the consumer.

2. **Vintage Date** (optional) – The year the grapes were harvested. If a vintage date is given, an appellation of origin smaller than a country must also be given. Specific rules apply regarding the percent of the grapes that must be from the designated year.

3. **Appellation of Origin** (optional) – The place where the dominant grapes used to make the wine were grown. It can be the name of a country, state, county, viticultural area (see Appendix C) or their foreign equivalent. Specific rules apply regarding the percent of the grapes that must be from the designated appellation.

4. **Varietal Designation** (optional) – Name of the dominant grapes used in the wine. A varietal designation requires an appellation of origin and means that at least 75% of the grapes used to make the wine are that variety and they come from the stated appellation. Wine labels are not required to have varietal designations. Other designations, such as Red Wine, White Wine, or Table Wine, may be used to identify the wine.

5. **Name and Address** – The name and address(es) of the bottler or importer must appear on the label. Domestic wines will state "Bottled by:" followed by the name and address of the bottler. The qualifier "Produced" may be used if not less than 75% of the wine was fermented at the address given. The term "Vinted" may be used if the wine was subjected to cellar treatment at the stated address.

6. **Net Contents** – The amount of product in the container is given in metric units.

7. **Alcohol Content** (optional) – Percent of alcohol by volume is generally given on the label.

8. **Estate Bottled** – The term "Estate Bottled" means that 100% of the grapes used in the wine were grown on land owned or controlled by the winery. The winery must crush and ferment the grapes, finish, age, process and bottle the wine on their premises. The winery and the vineyard must be in the same viticultural area.

9. **Country of Origin** – This statement is required on all imported wines. For imported wines, the name and address statement (#5 above) will state "Imported by:" followed by the name and address of the importer.

10. **Declaration of sulfites** – Required on any wine intended to be sold in more than one state that contains 10 parts per million or more sulfur dioxide. This statement is not required if the wine will only be sold within a single state.

11. **Health Warning Statement** – All alcoholic beverages containing 0.5% or more alcohol by volume must carry this statement. The statement must be separate and apart from other information on the label. "GOVERNMENT WARNING" must appear in capital letters and bold type while the remainder of the statement may not be in bold type.

Appendix E
Equipment Costs for Establishing a Winery

Data in the following tables were compiled by Mike Thomsen, Department of Agricultural Economics and Agribusiness, University of Arkansas Division of Agriculture; Justin Morris, Viticulture and Enology Program, University of Arkansas Division of Agriculture; and Andrew Post, Post Winery, Altus, Ark.

Table 1. Receiving and crushing equipment

Equipment Items	**Plant size** (annual fermenting capacity in thousand gallons) 5	10	20
Forklift & Pallet Jacks[1]	$850[1] *Pallet jack only*	$850[1] *Pallet jack only*	$8,850[2] *2 to 2.5 ton forklift & pallet jack*
Pallets	$70 *10 @ $7 ea*	$105 *15 @ $7 ea*	$140 *20 @ $7 ea*
Receiving Hopper & Auger with Frequency Drive	*None*	*None*	$6,000 *7-9 tons per hr.*
Crusher- De-stemmer	$3,500 *5.5 tons/hr*	$10,000 *11 tons/hr*	$18,500 *15-25 tons/hr*
Press	$6,000 *bladder press*	$12,000 *bladder press*	$32,000 *18 hl (475 gal)*
Must Pumps	NA *Crushed directly to the press or tanks*	NA *Crushed directly to the press or tanks*	$9,000 *3 inch rotating lobe*
Must Lines			$500 *100' of 3" hose@ $5/ft*
Cellar Hose	$1,219 *165' of 2" hose & 20 end fittings @$30 ea*	$1,219 *165' of 2" hose & 20 end fittings @ $30 ea*	$1,838 *330' of 2" hose & 20 end fittings @ $30 ea*
Total Cost of Receiving Equipment	$11,639	$24,174	$76,828

[1]May need to consider leasing a forklift during harvest if receiving mechanically-harvested fruit
[2]Cost reflects estimate for purchasing a used forklift

Table 2. Fermentation and storage equipment

Tank size (gallons)	**Plant size** (annual fermenting capacity in thousand gallons)		
	5	10	20
	Number of tanks needed		
250	8	8	8
330	2	2	2
440	4	2	2
550	2	2	6
880	2	2	2
1,000	-	2	2
1,200	-	-	-
1,250	-	2	1
1,500	-	2	1
1,800	-	-	1
2,000	-	-	1
2,200	-	-	1
2,500	-	-	1
2,800	-	-	1
3,300	-	-	1
3,800	-	-	-
4,400	-	-	-
4,800	-	-	-
5,000	-	-	-
5,500	-	-	-
6,100	-	-	-
6,600	-	-	-
6,800	-	-	-
8,800	-	-	-
10,000	-	-	-
55 gallon drums	10	10	10
Total tank costs	$37,600	$50,180	$84,500
American oak @ $320 ea	$7,360	$14,400	$28,480
French oak @ $550 ea	$12,100	$24,200	$48,950
Refrigeration	N/A *Self Contained*	$15,000 *5 ton system w/chiller 50 gal glycol tank, 3/4hp centrifugal pump*	$35,000 *25 ton system 1-15 ton 1-10 ton w/chiller 2hp circulation pump glycol pump*
Totals	$57,060	$103,780	$196,930

Table 3. Cellar equipment

Equipment Items	**Plant size** (annual fermenting capacity in thousand gallons)		
	5	**10**	**20**
Agitator	$10 *Oar or paddle*	$2,200 *Mech. agitator with fittings*	$2,200 *Mech. agitator with fittings*
Assorted Clamps and Fittings	$1,200	$2,400	$4,800
Cellar Pumps	$750 *25 gal/min flexible impeller*	$3,800 *80 gal/min centrifugal pump* $1,200 *70 gal/min positive displacement pump*	$3,800 *80 gal/min centrifugal pump* $1,200 *70 gal/min positive displacement pump*
Diatomaceous Earth Mixer and Doser	$10 *Bucket*	$10 *Bucket*	$3,400 *100 liter mixing tank & doser*
Plate & Frame Filtration	$5,700 *21-40cm plates*	$5,700 *21-40cm plates*	$6,800 *31-40cm plates*
Diatomaceous Earth Filtration	N/A	$11,300 *2 sq M*	$11,300 *2 sq M*
Barrel Washer	$300 *Midget or stenjorg*	$700 *Washer with stand*	$700 *Washer with stand*
Lees Filtration	N/A	$16,500 *20-30cm plate*	$16,500 *20-30cm plate*
Total Cost of Cellar Equipment	$7,970	$43,810	$50,700

Table 4. Bottling line equipment

Equipment Items	Plant size (annual fermenting capacity in thousand gallons) 5	10	20
Cleaning & Sparging	$400 *$CO_2$ bottle flusher*	$400 *$CO_2$ bottle flusher*	$400 *$CO_2$ bottle flusher*
Filling & Corking	$1,575 *Gravity*	$1,575 *Gravity*	$12,000 *Semi-auto in-line 4-spout 700 btls./hr.*
Capsuling	$225 *Hand-held heat shrink applicator*	$1,200 *Semi-auto heat shrink applicator*	$1,200 *Semi-auto heat shrink applicator*
Labeling	$1,500 *Standard manual labeler*	$5,500 *Semi-auto labeler*	$15,000 *In-line labeler*
Accumulator	N/A	$4,000 *Custom*	$4,000 *Custom*
Bottle Coder	N/A	N/A	$3,600
Case Closure	$150 *Staple gun or tape gun*	$150 *Staple gun or tape gun*	$150 *Staple gun or tape gun*
Case Coding	$270 *Serial number machine*	$270 *Serial number machine*	$270 *Serial number machine*
Total Cost of Bottling Equipment	$4,120	$13,095	$36,620

Appendix F
Useful Resources for Wineries

An important resource both for those just starting a winery business and those who are established is the research and extension personnel at colleges and universities across the country. Almost every state has someone working in areas related to grape and/or wine research and the information from these research efforts is generally readily available through county extension offices, state specialists, and/or via the Internet. A summary of the research conducted by the Grape and Wine Program at the University of Arkansas can be found in Appendix A.

Membership in professional organizations and participation in educational meetings are invaluable in helping a small winery operator learn about trends and technologies to establish and grow their business. Although membership dues in one or more of these organizations and the costs of attending annual meetings may seem like extravagances to someone just starting out, this is money well spent since the information gained and the networking opportunities provided will be invaluable. Predominant professional organizations and meetings for the wine industry include:

- **American Society of Enology and Viticulture** (ASEV) – The membership of ASEV includes professionals from wineries, vineyards, academic institutions and organizations working in the fields of grape production and wine making. ASEV publishes a quarterly journal, the American Journal of Enology and Viticulture (AJEV), which provides reports of scientific advances in the field. An Annual Meeting which is held each year in June includes technical sessions, research forums, symposia, and a supplier showcase and offers participants an excellent opportunity to network with other wine and grape industry professionals.
- **Eastern Section ASEV** – The Eastern Section was established to provide forums for research and technological developments related to grape and wine production in the Eastern United States and Canada (all states east of the western boundaries of Minnesota, Iowa, Missouri, Arkansas and Louisiana and the Canadian Provinces East of the Ontario - Manitoba border). Presentations and discussions of research and technology developments occur at the Annual Meeting in July. Members also are encouraged to publish findings in AJEV.

- **Unified Wine & Grape Symposium** – This Symposium began when ASEV and the California Association of Winegrape Growers joined forces to provide the wine industry with an opportunity to share information about research, trends and technologies. During the Symposium's three days of program sessions and two-day trade show, winemakers and grape growers are provided numerous opportunities to discover trends and discuss topics affecting the industry. This has become a "must attend" meeting for winery and vineyard operators.
- **American Wine Society** (AWS) – AWS was established to educate people on all aspects of wine. Members include grape growers, amateur and professional winemakers, wine appreciators, wine educators, restaurateurs and chefs, and anyone with an interest in wine. AWS publishes a quarterly AWS Journal as well as a quarterly newsletter and technical manuals, bulletins, and videos on various aspects of wine production and appreciation. AWS also sponsors wine competitions and offers training for those wanting to become wine judges. The Annual Meeting brings together professionals, serious amateurs, and novices to share information and experiences, and to explore the latest developments in wine and winemaking. For information on the AWS – Arkansas Chapter, contact Bob Cowie (http://www.cowiewinecellars.com).
- **WineAmerica** – The National Association of American Wineries. The mission of Wine America is to encourage the growth and development of American wineries and wine grape growing through the advancement of sound public policy. WineAmerica lobbies on wine industry issues at state, federal, and international levels and keeps members updated on issues through newsletters, public policy alerts, and various electronic communications. The annual Wine & Grape Policy Conference in Washington, DC provides an opportunity for participants to interact with one another and to meet Members of Congress and industry leaders.
- **Brotherhood of the Knights of the Vine** – This non-profit corporation seeks to promote the American wine industry and to educate members about the benefits and enjoyment of wine. Membership includes professionals in all phases of the wine industry as well as others who enjoy and want to learn more about wine. Membership is obtained when an existing Knight of the Vine nominates an individual who has made a major contribution to the wine industry. More information and a list of local chapters can be found at http://www.kov.org

Numerous books and other reference materials are available at libraries, bookstores, and, increasingly, on the Internet on the topics of growing wine grapes, winemaking, and marketing wines. The following list is just a sampling of some of the books available. Those entering the wine business are encouraged to explore the many references available and to build a reference library specific to their own interests and the grape varieties and wine styles they will produce.

- *The American Wine Society Presents: Growing Wine Grapes* by J.R. McGrew, J. Loenholdt, A. Hunt, H. Amberg, and T. Zabadal (1994, G.W. Kent, Inc.)
- *Winemaking: From Grape Growing to Marketplace* edited by R. Vine, E. Harkness, and S. Linton (2nd Ed., 2002, Springer)
- *General Viticulture* by A. J. Winkler, J.A. Cook, W.M. Kliewer, and L.A. Lider (2nd Ed., 1974, Univ. Calif. Press)
- *The American Wine Society Presents: The Complete Handbook of Winemaking by The American Wine Society* (1994, G.W. Kent, Inc.)
- *The Science of Wine: From Vine to Glass* by J. Goode (2006, Univ. Calif. Press)
- *Wine Analysis and Production* by B. Zoecklin, K.C. Fugelsang, and B. H. Gump (1995, Springer)
- *Successful Wine Marketing* by K. Moulton and J. Lapsley (2001, Springer)
- *Winery Utilities: Planning and Design* by D. Storm (2002, Springer)
- *From Vines to Wines – The Complete Guide To Growing Grapes And Making Your Own Wine* by J. Cox (1999, Storey Books)
- *Understanding Wine Technology – The Science Of Wine Explained*, 2nd Ed. by D. Bird (2005, DBQA Publishing)
- *Wine Science: Principles, Practice, Perception* by R.S. Jackson (2000, Academic Press)
- *Winery Technology and Operations: A Handbook for Small Wineries* by Y. Margalit (1990, The Wine Appreciation Guild Ltd.)

In addition to reference books, magazines, trade journals, and publications by grape and wine professional organizations can provide valuable information. Since these materials are usually published several times a year, the information they present is often more current than that found in books. In the discussion of professional organizations above, it was pointed out that most of these organizations offer one or more publications as part of the benefits of membership. There are also trade journals not directly associated with specific organizations that are available by subscription. In many cases a sub-

scription to current issues of magazines and journals also provides access to archives of past issues. Some of the trade journals for the grape and wine industry include:

Wines and Vines – A monthly publication offering news, information, and marketing and research reports. More detailed information on the magazine, other publications by the editors, and how to obtain these resources can be found at www.winesandvines.com

Practical Winery and Vineyard – This bi-monthly publication provides information covering all aspects of the wine industry from the vineyard to the cellar to the tasting room. Subscription information, indices of current and back issues, and access to key articles can be found at www.practicalwinery.com

Vineyard and Winery Management Magazine – This bi-monthly trade publication is designed specifically for the wine business professional. Articles cover all aspects of wine business including viticulture, wine technology, laboratory techniques, compliance, marketing, and public relations. Subscriber information can be found at www.vwm-online.com

Wine East – This bi-monthly publication provides information and news specifically chosen to be of interest to those who are growing grapes and making wine east of the Rocky Mountains. A sample magazine, archives, and subscription information can be found at www.wineeast.com

Wine Business Monthly – This trade publication focuses on reviews and discussion of issues and products affecting the wine industry. Its extensive product reviews and new product analyses give readers insights into the ever-changing world of wine making and marketing. Subscriber information can be found at http://www.winebusiness.com

American Vineyard – Although this publication focuses primarily on grape growing practices and winemaking in California, it presents news on wine, juice, raisin and table grapes that often affects the industry nationwide. Subscription information can be obtained at www.malcolmmedia.com/av.htm

Small Winery – This is a new magazine that developed as an outgrowth of the Small Winery Yahoo Group, http://groups.yahoo.com/group/small_winery/. The magazine has as its purpose to look at the special needs, problems and goals of small wineries and to provide a forum and source of information for addressing these. Subscription information can be found at http://www.smallwinery.us

As discussed in the text, it is strongly recommended that anyone planning to start a winery take the time to visit as many other operations as possible. People already in the business can provide good advice and excellent

ideas. They can help avoid some of the mistakes they made. Most people in the wine industry are more than willing to share their ideas and experiences with newcomers to the industry. Some wineries will let potential winery owners work with them for a day, a week, or a season to learn by doing. Such hands-on experience can give a better picture of the wine industry than almost any other experience.

Appendix G
Glossary

Anthocyanins – Pigments found in the skins of grapes and other plant materials that contribute red and purple colors. These pigments are responsible for much of the color of red wines.
Bacteria – Microscopic, single-celled organisms that live in soil, water, plants, organic matter, or the live bodies of animals or people. Depending on the organism present and the conditions, bacteria can be useful or may cause harm, such as product spoilage or worker illness.
Batch press – A press that presses one lot of grapes at a time as opposed to a continuous process.
Bentonite – An absorbent aluminum silica clay used to remove protein from wine.
Blending – Combining two or more wines for the purpose of adjusting the flavor, aroma, or other components to produce a more desirable wine.
Brix – A measure of sugar content. Since Brix is an indicator of ripeness, this measurement is used as a tool to help determine when to harvest grapes. Brix is also an indication of the potential alcohol in a wine when fermentation is completed; generally the higher the Brix in the grapes, the higher the alcohol in the finished wine.
Cap – The floating mass of skins and pulp that occurs at the top of the fermentation vessel during fermentation.
Carbohydrate – Chemical term for compounds made of carbon, hydrogen, and oxygen. The most common carbohydrates are sugars and starches.
Clarify – The addition of agents to wine in order to settle insoluble solids or suspended materials. Wine will also clarify during cold stabilization.
Cleaning – The removal of soil or other unwanted material such as fruit residues, dirt, and grease.
Enology – The science or study of wine and winemaking.
Fermentation – Converting the sugar in grape juice (glucose) into alcohol and carbon dioxide.
Filtration – The act of passing wine through a filter medium to remove suspended solids, yeast, and/or bacteria.
Fining – A method of clarifying wine by adding a coagulant to the wine and allowing it to settle to the bottom, carrying absorbed particles with it.
Free-run juice – juice that flows freely from grapes without the use of external pressure such as that applied by a press.

Gas sparging – Bubbling an inert gas (N_2 or CO_2) through juice or wine to reduce dissolved oxygen gas. Nitrogen may also be used to remove dissolved CO_2 before bottling.
Hard-press juice – Juice that requires pressure to remove. This juice usually comes from areas of the grape berry near the seeds and skins and often contains higher levels of phenols and proteins than free-run juice. Hard-press juice usually comes from the last press cycle.
Lees – The spent yeast cells that accumulate on the bottom of winemaking vessels after the fermentation is complete and the yeast have settled. Wine is usually racked (siphoned) off the lees to make it more presentable and to exclude any undesirable sensory effects that extended lees contact might impart.
Microorganisms – Organisms too small to be seen with the naked eye. Includes bacteria, viruses, yeast, and algae. Some microorganisms are beneficial and play key roles in the production of wine and other fermented products. Other undesirable organisms may be responsible for poor product characteristics, spoilage and other undesirable outcomes.
Must – Grape skins, pulp, seeds, and juice that is the end product of crushing grapes.
Muté – A fruity flavored juice added back to wine for flavor enhancement.
Pectins – Water-soluble carbohydrates from fruit that yields a gel.
pH – A measure of the acidity or alkalinity of a material. pH is measured on a scale of 1 to 14 with 7 being neutral. The lower the number, the more acid; increasing numbers indicate increased alkalinity.
Phenolic compounds – Chemicals occurring naturally in grapes that can affect such wine characteristics as color, flavor and mouthfeel. Assuring the presence of the appropriate phenolics in the proper proportions is one of the challenges of winemaking.
Pomace – Those portions of the grapes, including seeds, pulp, and skins, left after the juice is removed.
Potable water – Water that is free from impurities and considered safe for drinking.
Press juice – Juice obtained by applying pressure to the grape mass. Compare to free-run juice.
Pumping over – Pumping wine out from the bottom of a fermenting tank and over onto the top of the fermenting mass keeps the "cap" of skins wet. This process is usually done during fermentation of red wine in order to achieve complete extraction of the color and flavor.

Racking – Moving wine from one container to another, usually for the purpose of ridding the wine of sediment.
Sanitizing – Treatment of clean surfaces to reduce the number of potentially harmful microorganisms present to safe levels.
Sediment – Solid materials that settle to the bottom of tanks or bottles when juice or wine is allowed to stand undisturbed. These materials may be removed by filtering or by allowing them to settle and then racking off the liquid.
Sulfur dioxide (SO_2) – A preservative used in both must and finished wine since it serves to preserve aroma, flavor, and color. SO_2 also helps to inhibit the growth of microorganisms in wine. In recent years, there has been a trend to limit the amount of sulfur products used in winemaking because some consumers have experienced health issues when consuming sulfites. In addition, large amounts of sulfites can have a negative effect on wine flavor and pH.
Tannins – A group of phenolic compounds found in grape stems, seeds, and skins. The presence of these compounds contributes to astringency and bitterness in wine.

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