Cellar Hand Book.

An Education Primer for Cellar Work & Winemaking

First Edition

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Introduction

If you asked 100 winemakers how to do something in a winery, you would likely get about 100 different answers. The real difficulty of wine education is that at least 70 of those answers are right. Much like other crafts, there is no one way to make wine. This, of course, can make life difficult, never knowing what advice or guidance to trust. On the other hand, the variety of techniques, approaches, and theories about winemaking and climate create the multitude of wine styles and flavors that we enjoy today. This presents a challenge for wine education, however, among all these variations are some commonalities.

This goal of this text is not to teach as much of the "how" of winemaking but rather to identify these commonalities and help explain the "why" of certain winemaking practices. Understanding the background information leaves us better equipped to problem solve and react to the infinite number of situations that can arise in a winery. In particular, this handbook focuses on the equipment, techniques, and knowledge required during the harvest season for those just starting their winemaking careers. While this is by no means an "in-depth" review of each topic or all topics, it reveals some important background information that is hopefully both educational and helpful.

Scott Dwyer
Editor

Special Thanks

A special thanks to the Virginia Wine Board, without whom this project would not be possible. Many thanks as well to the dedicated members of the Virginia Winemaker's Research Exchange and the Wine Industry at large who wrote, edited, translated, and published this text. Virginia is a rapidly growing wine region, and with committed and motivated stewards such as these, it is likely to soon become a leading force in the wine industry.

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Comments/Questions

Given the subjective nature of winemaking described above, there will undoubtedly be those who read this book and either disagree with some of the text or have ideas for sections that should have been included but were not. Constructive feedback on both of these matters, or really anything, is greatly appreciated and accepted. This handbook exists to serve the Virginia wine industry, and feedback is essential to guide continued improvement so that it can keep pace with a changing landscape. Any comments or questions can be sent directly to the editor at winemakersresearchexchange@gmail.com

Virginia Wine Education Resources

In addition to wine growing and production, Virginia has a rich history of wine education. There are several community resources available for those wanting to continue reading and learning about wine production.

- Virginia Tech is home to one of the nation's most respected Fermentation Science programs. Along with educational programs, they provide a litany of resources, including Enology Notes. https://www.apps.fst.vt.edu/extension/enology/EN/index.html.

- Piedmont Virginia Community College in Charlottesville, Virginia, offers a series of courses in a variety of vineyard and wine topics. https://www.pvcc.edu/wine

- The Virginia Winemaker's Research Exchange publishes in-house experimentation from wineries across the state on a variety of enology and viticulture topics. http://www.winemakersresearchexchange.com

Chapter 1: Cellar Health & Safety

Introduction

Workplace incidents can have a tremendous impact on injured workers, coworkers, and families. Incidents can result in pain and suffering, disability, stress, and loss or change of employment. This section contains health and safety information for the wine industry. It will help prevent injuries and other incidents by describing specific hazards faced by winery employees and how to eliminate or reduce their impact. This guide provides a basic understanding of common winery hazards; however, it should not replace common sense, due diligence, or Occupational Safety and Health Administration (OSHA) requirements[1,2,3].

Responsibilities

To ensure a safe work environment, employers and employees must share responsibility. Both parties will need to address specific tasks:

Employers

- Ensure the health and safety of workers.
- Correct hazardous workplace conditions as much as possible.
- Inform workers about any hazards.
- Ensure that workers comply with the requirements of OSHA.
- Ensure that workers know their rights and responsibilities.
- Establish an occupational health and safety program.
- Provide and maintain personal protective equipment (PPE), devices, and clothing.
- Provide workers with education, supervision, and training specific to the workplace.

Workers

- Take reasonable care to protect your health and safety and that of others who may be affected by your actions.
- Comply with OSHA regulations and other legal requirements. Follow established safety procedures.
- Use any required PPE. Consult your supervisor if you are unfamiliar with the required PPE or how to use it.
- Refrain from horseplay or similar conduct that may endanger others.
- Do not work if impaired (for example, by drugs or alcohol). Report accidents and other incidents (such as near misses) to your supervisor.
- Report to your supervisor or employer any of the following:
    - A hazard that might endanger others
    - A problem with protective equipment or clothing
    - A violation of legal requirements
    - A coworker who is disregarding safety protocol and/or endangering others

Additionally, it is vital to be aware of your rights as an employee. If you feel like your safety is being compromised when performing a task, it is important to **refuse and report unsafe work.** Workers have the right to refuse unsafe work. If you discover a dangerous condition or believe you are expected to perform an unsafe act, you must immediately report it to a supervisor or your employer. A supervisor or employer who receives such a report should investigate the matter immediately. If there is an unsafe condition, it must be corrected without delay. Sometimes a supervisor or employer may not agree that a task is dangerous. In this case, consult OSHA regulations. In any case, employees must not be disciplined for refusing to perform tasks they have reasonable cause to believe are dangerous.

Hazards

This section describes common hazards in the wine industry and how to reduce the associated risks. Most workplace incidents are avoided by identifying hazards and taking steps to control them. Risk control involves eliminating the hazard entirely or minimizing the risks as much as possible.

I. Overexertion

More than one-fifth of injury claims in wineries and vineyards (22%) result from overexertion. These are most often back injuries that result from lifting, pushing, pulling, or carrying items that are heavy or awkward.

Prevention

- Place your feet apart for good balance.
- Bend your knees.
- Keep the load close to the center of your body.
- Use smooth, gradual motions.
- Avoid twisting your back.
- Rotate positions regularly if possible.

II. Sprains and Strains

One-third of injury claims are related to sprains and strains that don't involve the back. Sprains and strains can result from manual handling of items, such as carboys, cases, barrels, grape bins, or chemicals bags. These injuries can involve the fingers, wrists, hands, shoulders, knees, ankles, toes, or feet.

Prevention

- Organize storage areas by weight, with heavier items between knee and chest levels to minimize lifting.
- Use safe lifting techniques.
- Use dollies, pallet jacks, and forklifts whenever possible.
- If an item is too heavy, ask for help.

III. Wet/Slippery Surfaces

Slippery surfaces, such as wet floors and muddy or frosted ground, are a significant cause of injuries in wineries.

Prevention

- Wear well-fitting, non-slip footwear
- Clean and squeegee floors regularly
- Clean up spills immediately
- Install textured flooring, if possible
- Understand that certain areas, such as areas wetted with juice or detergent cleaner solutions, can be more slippery than the surface wetted with water.

IV. Falls from Heights and Ladders

A fall from any height can be dangerous, but a fall protection plan is required for any work at heights of 10 ft. or more. Falls from elevation account for 9% of all injuries in wineries and vineyards and 21% of the wine industry's total claims costs. They tend to cause more serious injuries than other hazards.

Prevention

- Tie off ladders when necessary.
- Use platform ladders and scissor lifts for work at heights, if possible.
- Where required, use personal fall protection, such as fall restraint or fall arrest systems.
- Use the right ladder for the job. Ensure it has the proper reach and weight capacity and meets the standard required for the workplace.
- Use a ladder that has slip-resistant feet. Set it on a firm surface that is flat and even.
- Check for defects and damage, such as bent or broken rungs or split side rails.
- Ensure that rungs or steps are clean and dry before use.
- When climbing, face the ladder and maintain three-point contact at all times (one foot and two hands on the ladder, or one hand and two feet).
- Don't stand on the top two rungs or steps of any ladder.
- If using an extension or straight ladder, extend the top of the ladder at least 3 ft. above the landing edge. Set the ladder with a slope of four vertical to one horizontal (i.e., for every 4 ft. of height, the ladder should be 1 ft. out from the base of the structure).
- Get down from the ladder to move it. Don't try to "hop" it into place.
- Always use a ladder as it was designed (do not climb on the backside of a step ladder, and do not use a step ladder as a leaning ladder).
- Do not stand on surfaces or objects that were not designed for climbing.

V. Tripping

Uneven ground, uneven flooring, obstacles in walkways, hoses, cords, and cluttered vehicle beds can cause falls that may result in a sprain, fracture, or even a head injury.

Prevention

- Perform regular site inspections of all areas in wineries and vineyards.
- Wear non-slip footwear that fits well.
- Keep walkways and work areas clear of tools, boxes, and other clutter.
- Don't carry more than you can safely handle.
- Be sure you can see where you're going when carrying large items.
- Watch for hoses and cords. If you're moving hoses, warn nearby workers.
- Keep work areas clear of tripping hazards, such as hoses, tools, and boxes.
- When hoses or cords must be in trafficked areas, maintain attention on/with obstacles until you have cleared the area.

VI. Unguarded Machinery

During regular operation, equipment such as electrical tools, tractor power takeoffs (PTOs), and conveyors can cause serious injuries. Guarding, when appropriately used, can protect workers from severe cuts, crushing injuries, fractures, and amputations.

Prevention

- Make sure all guards are in place before using the equipment.
- Don't wear loose clothing or jewelry near equipment with moving parts.
- Keep long hair contained.
- Check manufacturers' instructions for safe use.
- Be aware of emergency shut-offs for equipment being used.

VII. Industrial and Farm Vehicle Accidents

Five percent of worker injuries in wineries and vineyards result from accidents involving industrial equipment or farm motor vehicles, such as forklifts, tractors, and front-end loaders.

Prevention

- Perform a pre-use inspection.
- Ensure you understand the hazards and risk controls for the area in which you'll use the equipment (for example, slopes, narrow vehicle paths, or other workers or equipment).
- Use equipment that has a rollover protection system.
- Wear your seat belt when operating equipment and vehicles.
- Ensure you're rested and alert when driving.

VIII. Forklifts

Forklifts represent a hazard to all winery workers whether they are operating the machine or not. See Forklift Training in Appendix III.

Prevention

All forklift operators must receive proper training from a competent and qualified trainer and demonstrate competency to a supervisor or instructor. Forklift operations are discussed further in Appendix III. Regardless of who is operating a forklift, it is important that each person working in an area where a forklift is operating is aware at all times of the following:

- Raised forks (tripping hazard).
- Shifting Loads.
- Tipping when on uneven ground, slopes, and ramps.
- Approaching blind corners, doorways, or aisles.
- Horns, warning lights, and backup alarms.
- Obscured visibility from tall loads.

IX. Confined Spaces

A confined space is an enclosed or partially enclosed area that is big enough for a worker to enter. It's not intended for human occupancy and may have a restricted entrance or exit. Confined spaces in wineries and vineyards include vats, tanks, pressing equipment, dry wells, subterranean irrigation pumps, trenches, and excavations.

Prevention

Wineries should hire a qualified person to develop and help implement a written confined space entry program for your workplace. Confined space programs should accomplish the following:

- Assign responsibility for the program's administration to a person or people who are trained to manage it.
- Identify and develop an inventory of all confined spaces.
- A qualified person must assess the hazards for each confined space.
- Ensure that all workers entering a confined space are trained to do so. Training should include written rescue procedures.
- Post signs at all entry points to confined spaces.

In addition, employers should ensure there are safe work procedures for entry into and work in confined spaces. The procedure should address the following:

- Locking out energy sources and isolating adjacent piping.
- Ventilating the space with clean respirable air using appropriate mechanical venting equipment.
- Verifying precautions and testing the atmosphere with appropriate testing equipment before entry.
- Cleaning, purging, or venting the atmosphere, as appropriate.
- Using standby workers to check on the well-being of workers entering the confined space.

- Ensuring the area around fermentation tanks is free from hazardous levels of carbon dioxide.
- Use fixed monitoring equipment to monitor carbon dioxide levels of the room.
- For confined spaces on moving equipment, such as presses or mobile tanks, take additional lockout precautions to make sure equipment is not operable during entry of space.

X. Working Alone

When working alone, relatively minor injuries can result in major problems or even death if the worker can't get help quickly.

Prevention

- Implement a person-check procedure for anyone who works alone or in isolation.
- Ensure that workers know the early warning signs of a potentially hazardous situation.
- Ensure that workers are able to get help quickly if an incident occurs.

XI. Chemical Exposure

Many chemicals used in wineries and vineyards (for example, pesticides, cleaning solvents, and fuel) may cause conditions ranging from minor skin irritation to serious injury or disease. All workplaces that use hazardous products are required to document and have available the current safety data sheets (SDS, formerly MSDS). These sheets provide specific information on handling, storing, and disposing of hazardous products. Workers may request to view these sheets at any time.

Prevention

- Follow safe work procedures.
- Read labels and SDSs for hazardous products.
- Update the SDS for each product every three years.
- Ensure that all containers have proper labeling that identifies the contents.
- Store products in a properly ventilated, locked area. Post warning signs.
- Use PPE (for example, clothing, rubber gloves, goggles, and face shields) recommended by the manufacturer and required by safe work procedures.
- Before removing gloves, wash them underwater. Wash your hands after removing the gloves.
- Work in an adequately ventilated area with approved fire protection.
- Adhere to pesticide restricted-entry intervals.

XII. Compressed Gases

Compressed gases, especially those in high-pressure cylinders, offer additional hazards, compounding any issues from the nature of the gas in the cylinder. Safety precautions must consider both the chemical nature or potential for asphyxiation and the potential for the cylinder to become a projectile if the pressured gas is released in an accident. Examples include asphyxiating gases like Carbon Dioxide and Argon and chemical gases like sulfur dioxide.

Prevention

- Keep all cylinders stored in an OSHA-approved manner, secured to a wall in a low traffic area.
- When cylinders are not in use, keep them closed with safety covers.
- When moving cylinders, always move with an approved dolly, fully secured, and with a safety cover in place.
- Follow all OSHA guidelines for use.
- Develop an evacuation plan in the case of cylinder rupture.

XIII. Noise Exposure

Noise from bottling lines, open-air tractors, and some equipment (for example, crusher de-stemmers) can reach harmful levels and cause hearing loss. Noise-induced hearing loss is the most common occupational disease. You can sustain hearing loss by being exposed to a single loud noise or repeated exposure to a consistent noise. Hearing loss can be gradual and may happen over several years.

Prevention

- Workers can reduce the risk of injury by wearing approved hearing protection when entering areas posted as having high noise levels, whether or not it's noisy when they enter.

XIV. Electrical Hazards

Wineries use large amounts of both water and electricity, often at the same time. Damaged or frayed electrical cords present a significant risk for electrical shock in these conditions.

Prevention

- Inspect cords for signs of wear.
- Inspect electrical connections for integrity.
- Ensure extension cords are not damaged by equipment or forklifts.
- Be aware of electrical requirements for equipment.
- Know the location of circuit breakers.
- Ensure hands are dry and there is no standing water when using electricity.
- Audit all receptacles to ensure they are fitted with the right equipment to withstand water use in the area.

XV. Self-Care

Perhaps the most critical safety precaution at a winery, particularly during harvest, is self-care. Long hours and hard work can physically and mentally wear on everyone during the harvest season. It's important to maintain these faculties as best as possible.

Prevention

- Sleep – Sometimes, during harvest, sleep isn't as frequent as desired, but make sure to take advantage of the opportunity when it presents itself.

- Dry Clothes – A winery is a messy place to work; having an extra set of clean (and dry) clothes, especially socks, can make a long day a lot better.

- Food & Water – During long days heavy with labor, staying hydrated and fed is essential for physical health. Additionally, it's important for mental health and reducing avoidable accidents.

- First Aid – Beyond medical emergencies, the everyday wear and tear of work should be cared for to prevent exacerbation. Some common winery injuries include bruises, cuts, scratches, athlete's foot, bee stings, allergic reactions, etc. If you have a relevant medical condition (example: severe bee or wasp allergy), ensure you have any necessary medications and inform your employer as needed.

- Stress/Mental Health – Above all else, a winery can seem stressful and busy at times. It's crucial that everyone monitors their mental health and acts to maintain it. This could be as simple as taking a short break. Just be sure to tell your supervisor if you feel like this is necessary, so they can help support you.

- Footwear – Wear shoes or boots that are slip-resistant and sturdy. Insoles help to provide extra support.
- Sun Protection – If you are spending time outside in an un-shaded area, make sure to protect your skin with long sleeves, hats, and sunblock.

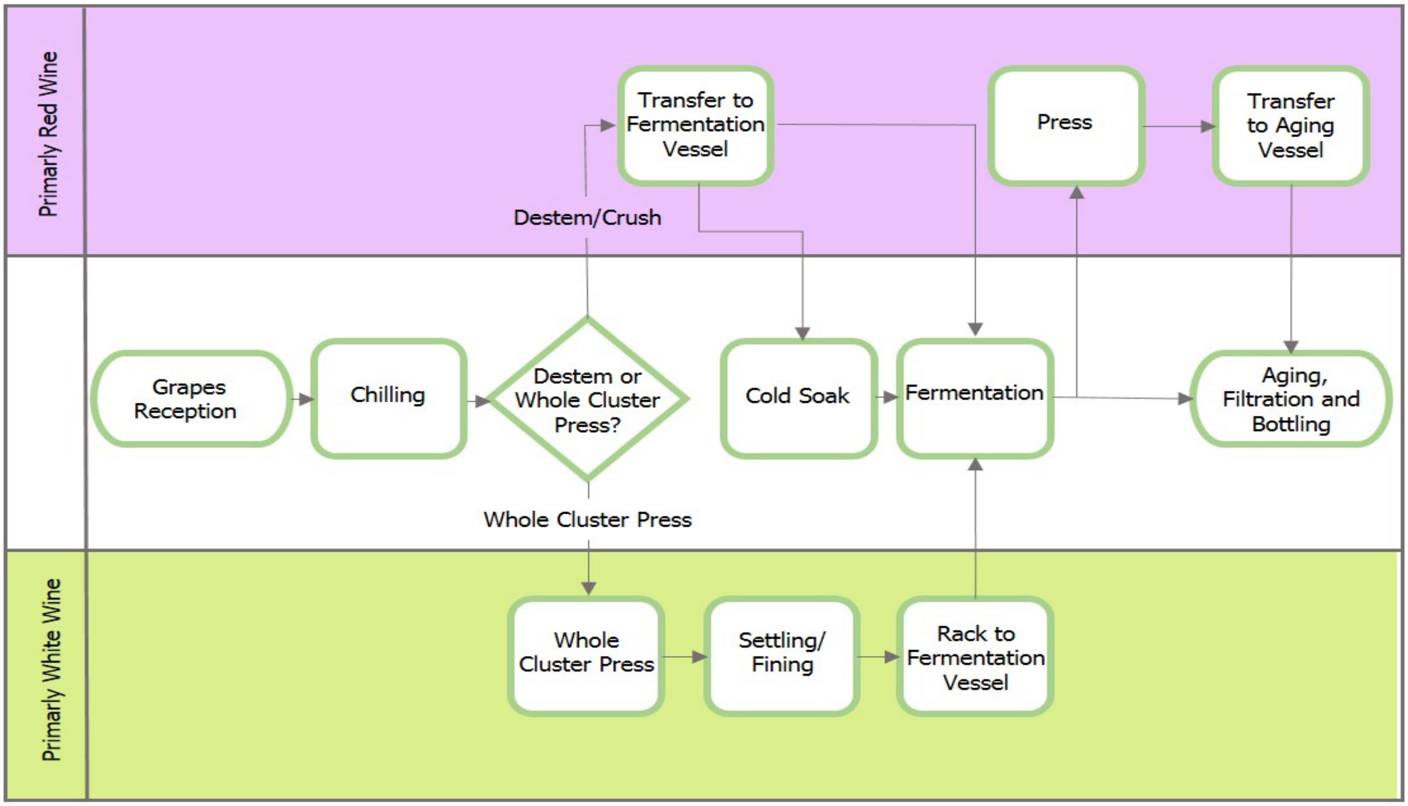
Conclusion

The importance of a safe work environment and everyone's role in achieving it cannot be over-emphasized. The joy of winery work disappears quickly in the face of a workplace accident. Avoiding such accidents by being aware and reporting hazardous situations is an essential component of everyone's job.

**** Please complete the Safety Orientation checklist located in Appendix II and return to your supervisor prior to starting work***

Chapter 2: Winery Work Flow

Work Flow Overview



Introduction

The intricacies of processing are often glazed over when discussing the grape to glass journey. Unfortunately, this is a disservice to the important and profound effect processing has on the final product. How fruit is processed considers a myriad of factors, including weather, staffing, tank space, winery space, and time. Additionally, it provides the first opportunity, in the winery, to define the style of the wine and significantly impact the finished product.

I. Picking/Transporting

Long before the first picking date has been set, it is imperative that a reasonable plan to transfer the fruit safely, efficiently, and economically from the field (where it was grown) to the facility (where it's made into wine) is set in place. The goal is to minimize the transport time between field and facility while keeping the fruit cool in order to prohibit spontaneous microbial activity and preserve the maximum value of the crop. Depending on the operation's size and goals, fruit is typically picked into lugs, bins, or gondolas. Each comes with its own advantages and disadvantages:

Lugs

Typically hold between 25 and 40 lbs. of fruit each, depending on the size and style. These durable plastic boxes long ago pushed the historic wooden boxes and straw baskets of old to the edges of the antique aisle. When empty, they can rotate 180 degrees such that they nest inside each other and can be more easily stacked on a pallet. Picking lugs are a great way to protect fragile fruit, and the ventilated sides and bottoms allow for efficient cooling and drainage. To transport without tipping and spilling the fruit, a good strapping system is mandatory. They are labor-intensive on the crush pad since each lug must be individually loaded by hand into the press, hopper, or sorting table and then cleaned.

Bins

Bins can hold anywhere from 250 lbs. to one ton of fruit, again depending on size and style. Typically, they can be purchased as either slotted or solid. Solid bins can double as a fermentation vessel and are also handy to have on the crush pad for transporting grapes from tank to press. Slotted bins are helpful for their ventilation capacity and allowing the juice from compromised fruit to drain. When fruit is clean, and the facility is set up with the appropriate equipment, bins present a less labor-intensive alternative to lugs.

Gondolas

Gondolas are most often used during mechanical harvesting to transport more significant tonnages of grapes from the field to the winery. They can be brought to the winery directly when applicable, or in the case of off-site vineyards, loaded onto a trailer for transport.

II. Receiving

Grapes must be received, unloaded, and weighed in a manner that is both efficient and accurate. Each pick will be assigned a lot number or code that will track the resulting wine until it is blended or bottled. These weights, once churned through the abacus of crush pad math, will determine many factors on the production side:

- The number of press cycles needed.
- The size and numbers of fermentation vessels to be used.
- The capacity of the tank or the number of barrels needed for aging.
- The dose rate of additives (SO_2, Enzymes, Tartaric Acid) to be added.
- Does the team get to go home before or after midnight?

In addition, everyone from the vineyard manager to the sales team will want to know this data. Along with its application to winemaking, it is critical for planning future costs, sales projections, wine club shipments, equipment orders, and tax responsibilities.

III. Storage/Chilling

Having the infrastructure available to control the temperature of the fruit is essential (Chapter 8). In addition to standard air conditioning and glycol chilling systems, wineries often rent refrigerated trucks during harvest or have a dedicated space for chilling fruit. Having control of the temperature puts winemakers in the driver's seat with a better ability to manage stylistic choices from the beginning rather than reacting to heat-driven forces. It can also allow work to begin the morning following a harvest day rather than late afternoon or evening once the fruit finally arrives at the winery.

Additionally, many winemaking facilities are in remote agricultural settings, often relying on rotary phase converters to provide the needed three-phase power. Since these electrical supplies are often at the end of the line, they experience the effect of every downed tree and lightning-struck utility pole upstream. When power is lost, active cooling is a challenge and often relies heavily on the use of dry ice.

A combination of clean fruit, picking during the cooler hours of the day, slotted picking bins, refrigerated transport and storage, and properly sized and functioning glycol chilling system are all tools that will keep the winemaking team in control of ferments.

IV. Processing Whites

White wines are fashioned in a vast array of styles, from the clean, crisp style of Vinho Verde or New Zealand Sauvignon Blanc to the rich, unctuous oaked Chardonnay. These stylistic choices are, in part, a result of decisions made during processing. The first of which is whether to break out the crusher/destemmer or go directly to press. This initial decision reveals two basic options:

Whole Cluster Press (WCP)

Whole bunches of grapes are put directly in the press. Since the grapes are neither destemmed nor crushed before entering the press, and the juice has minimal contact with skins or stems, there tends to be less bitterness and astringency in the resulting juice. The stems act as conduits, helping improve the efficiency of the juice flow to the pan. There is more clarity to the juice because fewer solids are released from the skins, given the gentler handling. Press cycles for whole cluster fruit are typically longer than those for crushed, destemmed fruit. However, pressing whole clusters on the same program as destemmed fruit generally results in higher yields. A superior juice often justifies longer press cycles with higher yields. The ability to make "cuts" is far better with WCP, meaning aliquots of juice may be separated or discarded. For example, if there is oxidized or acetic juice from compromised berries at the beginning of the cycle or heavy press juice with higher pH and more phenolics at the end of the cycle. Whole cluster pressing almost always leads to lower pH and higher total acidity.

Destem & Crush

With a crusher/destemmer, grapes move through a hopper to a rotating drum where the stems are removed using a counter-rotating paddle that moves the clusters fast enough so that the berry is detached from the pedicel (Figure 2.1). The berries then pass through a set of adjustable rollers that can be set to provide the desired level of crushing. The berries are then transported to the press, typically with either a must pump, elevator, or solid bin that will dump the contents into the press with a rotating head forklift.

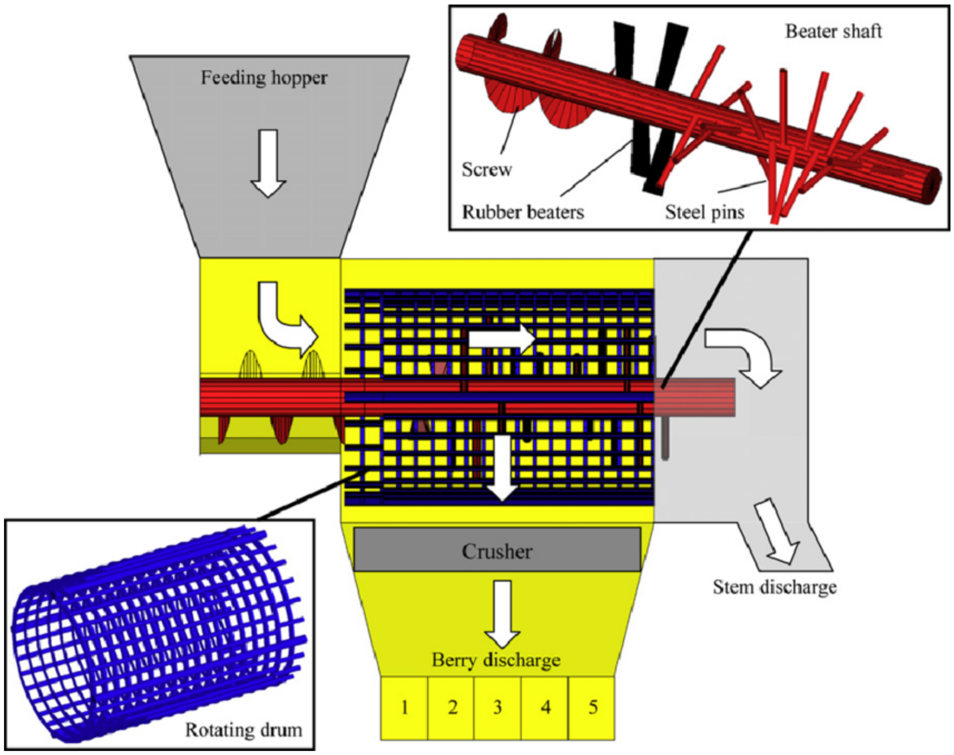


Figure 2.1 – Common destemmer/crusher design[1]

In addition to these two pressing options, the winemaker can alter oxygen management around the press pan to help achieve stylistic goals. Pressing can be done in a protective or oxygen-restrictive way to keep grapes and grape juice from oxidizing. It may also be done in a way that allows or even encourages oxidation. In general, aromatic, fresh, early-release white wines are protected from oxygen while more extended aging, full malolactic, textural wines are oxidatively pressed. Protection is generally done with inert gasses such as carbon dioxide in gas or solid form. More about the use of inert gases is included in Chapter 7. Three additional important factors to consider during white wine processing are:

Sorting

"Garbage in, garbage out" is a phrase that is readily transferrable to winemaking. To get good wine, you have to start with good fruit. Sorting using a vibrating sorting table or a conveyor belt provides an opportunity to remove “MOG” (Material Other than Grapes). This includes leaves, stems, picking knives, and clusters or berries that display imperfections such as sunburn, rot, raisining, or poor color. This final sorting is only meant to supplement the sorting work done throughout the growing season, where berries, clusters, and portions of clusters are constantly being evaluated and removed when necessary to facilitate the ripening process.

In general, white grapes are picked earlier to ensure appropriate acidity and are less exposed to the extended hang times and adverse conditions that lead to rot levels requiring sorting. Also, because white grapes generally do not macerate during the fermentation (orange wine excepted), there is less concern that leaves or variable ripeness in the fruit will contribute to off-flavors. There are always exceptions, but for these reasons, in general, reds require more sorting than whites.

There are significant capital, labor, and spatial expenses to consider when investing in sorting. In years with clean, evenly ripened fruit, very little may be required. In the most challenging years, the time and expense required to sort fruit must be balanced against other approaches to deal with fruit quality issues (press cuts, centrifuge, Rosé production, VA removal). When the decision is made to use a sorting table, it must be adequately staffed to ensure effective sorting.

Cold Soak

Cold soaking, ranging from several hours to several days, is employed to extract color, texture, and aroma that would not be possible using Whole Cluster pressing or Crush/Destem only. Grapes are typically destemmed and then crushed into bins or tanks with a target must temperature of less than 50°F. There are many variations on this basic theme: the inclusion of stems, maceration enzymes, tartaric acid, or sulfur that help define each practitioner's approach.

Juice settling and racking

In general, white juice is settled in the tank following pressing. Settling allows the winemaker to obtain desired clarity as measured by a turbidity meter or in percent solids. Depending on the textural and fermentation-derived character goals, the juice can be settled to high clarity, low clarity, or somewhere in between. Settling is generally aided with cold temperatures that also prevent microbial action. Some winemakers utilize products such as enzymes or fining agents to promote settling. Settling can take as little as four hours and as long as a week, though one to two days is the most common. Once desired clarity is achieved, the juice is moved off the solids (racked) to another tank.

V. Processing Reds

The same equipment and processing decisions used in white winemaking are considered in red winemaking. However, in white winemaking, fermentation typically happens *after* the grapes are pressed, whereas, in red winemaking, fermentation happens *before* the grapes are pressed. Rosé is included with white wines and Orange wine with reds to make this distinction work.

Destem & Crush

Red grapes are typically destemmed to remove the potential for "green tannin" and "stemmy flavor" in the wine. Following destemming, the winemaker has the option to crush the fruit or leave it as whole berries. Soft varieties such as juicy, juicy Malbec do not require much crushing at all. In contrast, the bullet-hard berries found in Pinotage and Norton require crushing to release juice to begin fermentation. Often winemakers will use the level or degree of crushing as yet another tool to affect the style of the finished wine. Following these steps, must is transferred to the fermentation vessel (tank or bin).

Whole Cluster/Carbonic Maceration

Whole Cluster Fermentation is possible in red winemaking as well and is usually accomplished through carbonic maceration. For carbonic maceration, whole cluster grapes are sealed in a fermentation vessel and layered with CO_2. This approach can add additional layers to the wine by gaining additional tannin and herbaceous notes from the stems and increased esters from the whole berries. These potential gains must be balanced against the potential for a higher pH, decreased TA, and increased microbial growth.

Additional Techniques

Before fermentation begins, some producers may employ the following techniques:

Saignée/Bleeding - A portion of the juice is removed before or at the start of fermentation to produce a darker, richer red by lowering the ratio of juice to skins and seeds. The removed juice is often used for Rosé production.

Cold Soak - Soaking the must before fermentation may help extract aroma, tannins, and color from the skins while limiting the extraction of tannins from the seeds. Duration ranges from a few hours to a few days. There is considerable risk for spontaneous yeast and bacteria growth as well as oxidation unless the cap is protected and temperatures are kept at 50°F or lower.

VI. Cap Management

Whole berry fermentation common to red wines requires additional maintenance to ensure a clean and efficient fermentation. The primary extra step is commonly known as "cap management." Carbon dioxide produced from fermentation will force a portion of whole berries to the top of the vessel, forming a dense "cap." Periodically the cap should be broken up and re-integrated to keep the skins in contact with the fermenting juice below. This is done to improve microbial stability, homogenize temperature, and allow various levels of color and phenolic extraction depending on the technique used. Standard methods for cap management are:

Punchdown

Grapes are pushed from the top of the fermentation vessel back down into the fermenting juice below. It becomes progressively easier but less necessary as fermentation progresses and the skins begin to break down. A handheld tool (Chapter 4) is often adequate for punchdowns of bin fermentations. Hydraulic systems are available for larger fermentation tank sizes where the cap can be difficult to penetrate.

Pumpover

A pump is employed to moisten the cap by transferring juice from the bottom to the top of the tank. Rotating sprinkler systems are available that uniformly wet the cap. Many producers take advantage of the opportunity to add air to the fermentation, which can be beneficial to yeast and lessen potential reductive aromas while encouraging tannin polymerization.

Rack and Return

Juice is removed from the fermentation vessel and transferred temporarily to another vessel. The juice is then returned. There are many versions of this, each with a slight variation on the goal. Examples would be introducing oxygen, removing seeds, or managing temperature.

Pneumatic

Systems such as Pulsair break up the cap from below using pulses of compressed gas. This technique is typically used when a gentler intervention and less extraction is desired.

Conclusion

Processing is an essential step in winemaking and an excellent opportunity to begin defining the finished product's character and style. Within the tools, techniques, grape varietals, and wine styles, there are numerous combinations of processing procedures available. Understanding each one's purpose and how they relate to surrounding variables is a critical aspect of winemaking practice.

Chapter 3: Cleaning and Sanitation

Introduction

One of the most important factors influencing the quality of wine is the cleanliness of the cellar in which it is produced. There is an adage in the wine industry that 90% of winemaking is cleaning. However, anyone who has worked in a cellar would likely consider that a low estimate. Most of the cellar tasks revolve around cleaning simply to ensure that the yeast and bacteria wanted in the wine predominates and those not wanted have little chance of surviving.

Presumptively, most humans have made it to adulthood with some knowledge of how to clean things, but often with varying ideas of when and why it is necessary. This chapter will introduce the tools most wineries will use to maintain cleanliness. Though specific protocols will undoubtedly vary from winery to winery, the methods and principles outlined here are essential for maintaining high production standards.

I. What is Clean?

There are a variety of terms interchangeably used to describe cleanliness. However, in the context of wineries and equipment, it is important to define precisely what these words mean and when they should be used[1]. The primary terms used to describe levels of winery hygiene are as follows:

Cleaning – Cleaning is the removal of dirt using mechanical and chemical means. Cleaning includes everything from wiping down a dusty surface and brushing the inside of a tank to sweeping the floor. Physical cleaning and dirt removal are the first and most important steps in maintaining a quality cellar. Furthermore, without an initial cleaning, it isn't easy to sanitize properly.

Sanitization– Sanitation is the process of removing a significant population of microorganisms from a surface or object using heat, chemicals, or other interventions. The purpose of sanitation is reduction, not elimination, and will significantly hinder a microbial population's capacity for replication. The word sanitation is often used interchangeably with sterilization, but they are very different.

Sterilization – This is the process of removing ALL microbes from a surface or object, which requires sustained high temperature and pressure. Due to the transient and challenging nature of sterilization, this is the least common level of cleanliness required in a winery. However, it is critical for specific parts of the process, such as filtration and bottling.

II. When to Clean?

Always.

Well, almost always. The answer to this question will vary from winery to winery, but in general, when in doubt, clean. Equipment and tools are generally cleaned before and after each use. An exception to this rule is choosing to not thoroughly clean the press between loads, but only at the end of the day or after a long stretch of use. A good rule of thumb is that if there is no overt task at hand, chances are there is something that needs cleaning.

5-Second Rule

While most people grow up with some version of this rule, and many have eaten some unfortunate dog hair-covered chocolate when no one was watching, there is no 5-Second Rule in a winery. Given the number of fittings and the amount of water involved in winemaking, things get dropped easily and often. Unfortunately, the floors and drains are among the least clean parts of a winery, usually coated with several layers and types of microbes. If it touches the ground, it needs to be cleaned before it touches the wine.

III. How To Clean?

Before starting to clean, evaluate the condition of the equipment or location. For example, a wide range of conditions can be found in a recently emptied tank. On the cleaner end of the spectrum, a little wine residue with no known spoilage issues. On the dirtier end, dried on grape skins and tartrates. Therefore, it is critical to inspect the tank closely (sight and smell). Use a flashlight and look at all the interior surfaces of the tank. Do not look, hoping not to see dirt/tartrates/etc., or something will be missed. **Instead, look at all the surfaces determined to find any dirt or residue that is there.** While specific winery protocols will vary, the process of cleaning follows a general pattern with the following steps:

Pre-Rinse

As soon as a piece of equipment is no longer being used and before any organic material dries, rinse the equipment with water to dislodge large chunks of debris and other organic material. Rinsing is typically most effective with warm water, if available. Keep rinsed equipment wet until cleaning begins, and start cleaning it promptly, similar to dirty dishes in the kitchen sink, dried on sugars and proteins are harder to remove.

Cleaning (Washing)

Cleaning involves manual scrubbing and the use of a chemical cleaner. The type of chemical cleaner used depends on the type of dirt or residue being removed. A detergent cleaner with a basic pH (caustic) is often used at this step, commonly sodium peroxycarbonate. How to wash will depend very much on what is being washed, but general principles include:

- Agitation and cautious rubbing will significantly facilitate the washing process. Make sure that whichever tool is used for scrubbing is sufficiently non-abrasive so that it will not scratch the surface of your equipment. Scratches may make the equipment more difficult to wash in the future and harbor microorganisms and other contaminants.

- Easily accessible surfaces, like the sides of tanks, are generally easy to clean. Inaccessible or difficult to access surfaces, like the underside of tasting valves, are the real challenge. If left dirty, these become a breeding ground for bacteria and mold that could then infect future lots of wine. Keep a flashlight on hand to check these harder to clean areas.

- If the cleaning solution gets very contaminated or loses efficacy, dump it out and make a new solution. Many solutions can be tested for concentration or pH with test strips. If these are available, use them regularly and know the limits of effectiveness to ensure you are getting the most out of your cleaning efforts.

- Before moving on to sanitizing, ensure that all surfaces are thoroughly washed and rinsed. Remember: sanitizing agents are not likely to sanitize dirty surfaces effectively. Never mix a washing agent with a sanitizing agent to speed the process — it does not work.

Post-Rinse

Use water to removes particles that have been loosened through scrubbing as well as any caustic residue.

Sanitizing

Sanitizing requires the application of an antimicrobial agent. Sanitize with a suitable sanitizing agent, at the proper concentration, and compatible with the type of equipment being sanitized. Some sanitizing agents consist of very aggressive oxidizing chemicals that should effectively sanitize clean surfaces in less than ten minutes. Soaking equipment in such sanitizers for long periods is generally unnecessary and can damage equipment.

Final Rinse

A final water rinse removes the chemical residue left after cleaning and sanitizing steps and balances pH. Some non-toxic sanitizing agents do not require a water rinse (example: Star San). After the final rinse, drain the equipment thoroughly and ensure that it is free of visible dirt and odors. If either is still present, cleaning should be repeated.

IV. Cleaning Agents

Cleaning agents are often described as matched pairs with various categorizations: Cleaning and Sanitizing, Caustic and Acidic, Base and Acid, etc. Like many aspects of winemaking, there is a considerable variation in what chemicals people choose and why. This section will review the use of some common chemicals; however, an exhaustive list is beyond the scope of this chapter. If a winery uses agents not listed below, ask the winemaker about their specific activity.

Not all cleaning or sanitizing agents are compatible with every type of material found in a winery. An agent suitable for use with stainless steel, sodium hydroxide, for example, may severely damage glass, PET (polyethylene terephthalate), oak, food-grade plastics and rubbers, and other types of materials, or vice versa. Cleaning and sanitizing agents often do not come with sufficient and useful information to help make informed decisions about which to use with what materials and under what conditions. For this reason, it is essential to follow the established cleaning protocol of each winery.

Preparing Chemicals

Prepare selected cleaning agents according to winery protocol. Be sure to use concentrations in line with the manufacture's recommendations. Typically, wineries will have containers used explicitly for cleaning chemicals ranging from plastic bins to stainless steel sumps. Water temperature must be appropriate for the chemical(s) at hand. Additionally, appropriate PPE should be worn at all times when handling cleaning chemicals. The concentration of many cleaning agents can be measured using test strips. If required, test after preparing a solution to ensure an effective (and not harmful) concentration is achieved.

Chemicals for Cleaning

Alkaline chemicals, commonly referred to as "caustics," are high pH (basic) chemicals used during cleaning. These products can contain several "active" ingredients, including oxidizing agents such as hydrogen peroxide, alkaline chemicals (caustics), surfactants that break down dirt and greasy residues, and chelating agents. Surfactants (short for surface-active agent) are hydrophilic-hydrophobic compounds capable of lifting and dispersing dirt by lowering the surface tension of a liquid, allowing easier spreading, and lowering the tension between two liquids or between a liquid and a solid. Detergents, foaming agents, and wetting agents are examples of surfactants. Chelating agents, such as phosphates, are chemicals that sequester minerals, the culprits in hard water.

Sodium Carbonate and Sodium Percarbonate

Both are very effective at dislodging heavy deposits from tank walls or removing greasy residues. For this reason, they are two of the most common alkaline chemicals found in cleaning products. These products often incorporate surfactants or sodium metasilicate, an effective flocculant used in wastewater treatment, inhibiting corrosion. These are commonly used for cleaning tanks, fittings, gaskets, barrel wands, and much more in the winery.

Sodium Hydroxide (caustic soda) and Potassium Hydroxide (caustic potash)

Both are very effective for washing tanks. A weak solution with a short-soak period followed by a light scrubbing will work well for most stains. An increased concentration can be used for tough stains, but be careful as these chemicals are very corrosive and detrimental to many other metals and materials, especially glass. They are also extremely hazardous to humans. Risks include permanent skin burns and blindness. Proper PPE should always be used.

In all cases, a thorough rinse with an acid solution (usually citric or tartaric) is recommended to neutralize any alkaline residues after cleaning.

Chemicals for Sanitizing

Sulfur

Sanitizing products incorporate a range of chemicals that inhibit or kill contaminating microorganisms. A commonly used sanitizing solution is generally referred to as "citric & sulfur," a low pH (acidic) solution that uses sulfur dioxide (SO_2) as an antimicrobial agent, disrupting the cell membranes of bacteria. Potassium and sodium metabisulfite (KMBS and NaMBS, respectively) are the most widely used source of sulfur; however, pure SO_2 gas is available from some suppliers. The citric acid lowers the pH of the solution, increasing the effectiveness of SO_2 as an antimicrobial agent (Chapter 7).

Sulfur dioxide is a volatile gas and will evaporate out of solution if it is not used and stored properly. Though sulfite powder dissolves much more readily in hot water than cold, its use is not recommended as SO_2 will volatilize in warmer water, reducing the solution's effectiveness. Sulfur solutions can be reused for several weeks if stored in an adequately stoppered container stored at cellar temperatures (15°C). At room temperatures SO_2 will slowly volatilize, rendering the solution ineffective. It is common to see spray bottles of a 5-10% citric/sulfur solution floating around the winery for sanitizing valves and fittings. Given the short shelf life of such a solution in ambient conditions, this is generally an ineffective sanitization measure unless refreshed frequently.

Acid

Acid sanitizers, such as phosphoric acid, are also effective as they can disrupt cell membranes in microorganisms. They are used extensively in the food and beverage industry because they leave equipment in an acidic condition that eliminates water spots. Star San and Saniclean are examples of acid sanitizers that use phosphoric acid and incorporate surfactants and are therefore often recommended as one-step cleaner/sanitizers. Oxy-San is a similar product, which also contains hydrogen peroxide, sodium metasilicate, and surfactants. The main disadvantages of using acid sanitizers are that they are corrosive to soft metals and may kill only selected microorganisms, potentially leaving behind others that can cause spoilage later.

Peroxyacetic acid (PAA), found in such products as Oxy-San ZS, is an excellent bleaching alternative to chlorine and chlorine dioxide sanitizers. PAA is considered eco-friendly because it breaks down into acetic acid and hydrogen peroxide with minimal foaming, which does not require rinsing. It is recommended where soft water is not available. PAA acts very quickly, but it has a pungent odor and is very expensive relative to other sanitizers.

Other

- Bleach - Bleach (chlorine) solutions **should never be used in or near a winery**. Beyond environmental side effects, chlorine gas, combined with other compounds, can cause the production of 2,4,6-trichloroanisole, better known as TCA, the compound responsible for the moldy, musty smell of "corked" wines. All cleaners with a chlorine component should be replaced if possible. Diversol BX/A, a widespread chlorine-based product used by home winemakers, should be avoided. Trisodium phosphate "TSP" is a potent and effective alkaline chemical used in many wineries, though it is important to use the non-chlorinated version.

- Iodophors - Iodophors are sanitizing agents and surfactants containing iodine. Though typically considered less of a culprit in causing cork taint, any volatile or gaseous chemicals containing iodine, bromine, or any other Halogen group element should be avoided if possible.

- Alcohol – Ethanol mixed with water (70%/30% respectively) is a common sanitizing agent in wineries. Along with the 5-10% citric sulfur blend mentioned earlier, 70% alcohol can also be found in spray bottles scattered around most wineries. Unlike the citric sulfur solution, the ethanol mixture does not lose efficacy over time. When using this solution as a sanitizing agent, it is important to note that the concentration (70%) and the contact time are critical to its success. Dilution to 70% provides the solution with the ideal balance of water and ethanol. This balance ensures the evaporation rate provides adequate contact time and that the alcohol is concentrated enough to kill a broad spectrum of microbes. In short, this solution is most effective when sprayed on valves or fittings and allowed to air dry.

Safety

Though safety is covered in depth in Chapter 2, it is important to mention here that all cleaners and sanitizers can be hazardous. Always read the instructions and use them safely. Never mix chemicals unless permitted by the manufacturer. In some cases (such as mixing ammonia with bleach), mixing chemicals can release toxic fumes. Only use chemicals in a well-ventilated area, and always wear proper PPE.

The Safety Data Sheet (SDS) for each product will supply information about its safe use, including first aid. These sheets are easily searchable on the internet and should be made available by the employer if specifically requested. Always follow the instructions for how to use and dispose of chemicals in the winery.

V. Cleaning Equipment

In addition to chemicals, most wineries have a variety of cleaning equipment. Physical agitation of dirt and debris is paramount in cleaning, and accordingly, it is vital to have the proper tools. Unfortunately for the mystique of wine production, these tools are not unique, simply what would be found at any other production facility. However, it is worth mentioning a few pieces of standard equipment:

Brushes

- Brushes come in as many shapes, sizes, and functions as wine. It is important to match the form and function of the brush. It would be inefficient to clean a floor with a bottle brush, but often it's hard to fit a floor brush into a carboy.

- Some brushes are sequestered for specific tasks. For example, a brush for cleaning tanks may not be used to clean floors. Keeping brushes separated based on their purpose can help minimize unintended cross-contamination.

- Brushes need cleaning. Like all winery equipment, brushes should be cleaned as needed and at the end of the day by rinsing and chemical cleaning. There are lots of places for microorganisms to thrive among the bristles.

- Allowing brushes to dry between uses or at the end of the day is essential to maintain cleanliness. Mold and bacteria can begin growing within a brush if it is not adequately cleaned and allowed to dry. These microbes can then be spread to other surfaces turning the brush into a vector for infection rather than a cleaning tool.

Power Washer / Pressure Washer

- Often a crucial piece of equipment for cleaning a press, hopper, de-stemmer, or other machines with a myriad of nooks and crannies.

- High pressure can damage motors, press bladders, and some seals. It is important to know what can and cannot be sprayed with the power washer.

- Pressure washers have a wide range of power depending on the specific model. However, it is crucial to operate every model with high regard for safety. DO NOT use a power washer to spray body parts. Serious injury can occur because of the extreme water pressure.

- As with any machine, care and maintenance are required, and proper use matters. A common mistake is attempting to operate a power washer without water flow (i.e., a closed or disconnected valve). Running the power washer without a water supply can cause permanent damage to both the pump and motor.

Conclusion

It is impossible to stress the importance and prevalence of cleaning in the winemaking process. Many newcomers to the wine industry are surprised at how much cleaning occupies their days. Initially, this comes off as some sort of punishment, particularly because the least experienced staff are generally tasked with the bulk of the cleaning. However, cleaning is crucial to the success of a vintage. As harvest progresses, it becomes more and more difficult to approach these tasks with continued enthusiasm. Diligence in ensuring a clean environment regardless of enthusiasm is critical (see 5-Second Rule above).

Chapter 4: Equipment

This chapter will provide brief descriptions of common winery equipment. There are numerous variations of each piece listed, however, their general function is roughly the same. Not all wineries will have everything listed here, but it is important to know what equipment exists and where it is used in the process.

De-stemmer- Removes stems from grapes and usually has an option to crush grapes following destemming. The crushing operation is typically adjustable, allowing for more or less crushing[1].

Hopper – Giant metal funnel used to direct grapes into machineries such as a de-stemmer or press[2].

Sorting table – A table that conveys grapes while individuals remove undesirable bunches or berries. If sorting clusters, the table is set up in front of the destemmer. If sorting berries, the table is set up after the destemmer. Typically has adjustable speed[3].

Optical Sorter – A type of sorter that uses an optical reader to separate under-ripe and potentially diseased berries from the lot[4].

Press

Bladder/Pneumatic – Separates grape juice from grape skins by inflating a rubber bladder with air and pressing grapes against steel plates with sieve-like openings. Juice falls to a pan below and is typically pumped to a tank. Press operations include many cycles of increasing pressure with the drum rolling in between to mix the grapes[5].

Basket – Separates grape juice from grape skins by pushing a metal plate onto grapes sitting in a slotted basket[6].

Glycol Pump– A refrigeration (or heat) unit with a pump and compressor that cools/heats liquid glycol circulating through a system of pipes or hoses attached to tanks. It is available in a wide variety of sizes, including small portable units, depending on the demands of the winery[7].

Pressure washer - Machine that uses a pump to dispense water at high pressure, commonly used for cleaning in a winery (Chapter 3). Can have hot functionality powered by fuel, gas, or electricity. Commonly referred to as a "hot cart" if contained in a single unit (pictured). Must always be used in conjunction with water flow[8].

Tank cleaner/sprayer – A stainless-steel fitting with a rotating head attached to a wine hose or water hose and inserted into a tank for cleaning[9].

Pallet jack – Mechanical or electric device that uses hydraulic force to allow an individual to lift and transport heavy items such as Macro Bins of fruit, small tanks, and pallets of glass or bottled wine. Usually with a carrying capacity of around 5,000lbs[10].

Pump- Used for moving must, juice, or wine. Available in many configurations and sizes depending on need (Chapter 5)[11].

Wine Hoses – Special hoses for the transport of wine. Typically reinforced to prevent exploding from the pressure created by the pump and ensure durability as they are moved around the winery. Available in a variety of materials and configurations[12].

Attachments

Tri-Clamp – ("tri-clover") A common attachment system for hoses, fittings, etc. Come in various sizes, require a gasket to seal the connection, and is tightened with a clamp[13].

DIN – Another standard attachment system that is threaded. Not commonly used in American wineries[14].

Valves – Used to control the flow of liquid. For a description of various valve types, see Chapter 6[15].

Barrel Wand - A shaped stainless-steel tube that attaches to the end of hose and fits through the bunghole of a barrel. Used to rack or transfer wine out of or into a barrel. There is often a set screw on the end to set the racking height[16].

Bulldog – An alternate style of barrel wand that dispenses compressed gas (nitrogen) into a barrel to push wine out through the hose rather than using a pump. It is considered a significantly less oxidative method of movement compared to a pump[17].

Racking Arm – Angled stainless-steel tube that connects to a hose and aids in racking must or wine from a tank. Often, they are equipped with two clamp attachments so they can be placed in a tank through a ball valve before filling the tank[18].

Sparging stone – A porous stone used to stir or mix a tank of wine when compressed gas (usually nitrogen) is passed through[19].

Punchdown tool – A stainless steel plate mounted in a staff used to push down the cap of fermenting grapes. They can be operated manually or hydraulically[20].

Filters

Plate and Frame – Wine runs across a series of alternating plastic plates and filtering pads composed of cotton, cellulose, diatomaceous earth (D.E.), or manufactured fibers like polyethylene[21].

Crossflow - Wine is pumped tangentially across a membrane surface. As the feed flows across the membrane surface, filtrate passes through while concentrate accumulates at the opposite end of the membrane[22].

Membrane - Wine runs through a cartridge composed of nylon, polypropylene, cellulose esters, or glass fibers. Primarily used for microbial stabilization and is frequently the final filtration step before wines are bottled[23].

Microfiltration - (RO & Sweetspotter) – Uses pressure and tangential flow across a semi-permeable membrane to separate some elements of a wine[24].

Centrifuge - Machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities or liquids from solids. Larger centrifuges can be used to remove solids from grape juice or fining agents such as bentonite[25].

Guth Mixer – Motor with an extendable propeller inserted into a tank through a ball valve to agitate or mix the contents[26].

Bins

Lugs – A genre of plastic bins that come in various sizes used while picking grapes[27].

Macro Bins – A general term for bins designed for picking grapes and fermentation made by a company called Macro Plastics. They are sized by height and can typically have solid side or slotted sides[28].

Measuring Brix (Sugar)

Hydrometer - Used for measuring the relative density of liquids (must and wine) based on the concept of buoyancy. They are typically calibrated and graduated with one or more scales, such as specific gravity or Brix[29].

Refractometer - Measures the degree to which the light changes direction, called the angle of refraction. Refraction angles correlate to refractive index and can be used to determine the concentrations of sugar in must and wine. Must be calibrated with distilled water and kept clean[30].

Densitometer – Digital handheld device that measures the density of must and wine using oscillation frequency of a known sample volume. Very accurate when measuring juice, but also fragile and expensive. Do not carry it on a cart (vibrations can damage the measurement chamber), drop, or hit it against a tank or barrel[31].

Chapter 5: Pump Operations

Introduction

One of the main infrastructural and economic questions for any winery is how to effectively and efficiently move juice and wine. Generally, the most common method is using a pump. While pumps all share a similar purpose, they vary in design to suit specific functions. This chapter aims to provide a brief overview of the various pump operations and become familiar with the types of pumps seen in a winery.

I. Common Pump Operations

Cleaning

It is essential to clean pumps and their associated hoses before and after use and in accordance with winery protocol. For everyday use, it is important to have a pump that can be cleaned quickly and effectively.

Transferring Must

With the proper pump destemmed whole or, crushed berries can be transferred into a fermentation vessel. Once fermentation is complete, the same pump could be used to transfer the wine and berries into a press. Typically, larger impeller or rotary lobe pumps are used for must transfers.

Pumpovers

As discussed in Chapter 2, pumpovers are a common form of cap management. Fermenting must is pumped from the bottom of a tank or bin onto the cap of solid berries. Any pump can be used for pumpovers assuming a filter of some type is employed to keep solids from the intake hose. Alternately a pump capable of moving whole berries can be used.

Racking

The process of removing liquid, either must or finished wine, from solids at the bottom of the vessel, is called racking. Wine or juice can be racked from a tank to a barrel or a barrel to a tank. It is common to employ the use of a racking arm for tanks (Chapter 4). For barrels, it is common to use a barrel wand to rack (or transfer) wine from a barrel. A "bulldog" can also be used, relying on moving wine with compressed nitrogen rather than a pump. Speed control is essential when racking to ensure clean and efficient racking.

Transferring

Transferring is simply the process of moving grapes, must, or wine from one place to another without racking. This can be done for a number of purposes. The ideal pump for transferring is gentle on the wine, such as a rotary lobe pump, moineau pump, or diaphragm pump.

Barreling Down

This is a common term for filling barrels, and can be done prior to alcoholic fermentation, prior to malolactic fermentation, or following the completion of both (Chapter 10). Similar to racking, when barreling down, it is important to have a pump with speed control. Wine traveling through a barrel wand at high speed when initially filling a barrel will be aerated similar to water coming out of a hose. Once the level of the wine has increased to cover the barrel wand outlet adequately, the speed can be increased. As the liquid nears the fill height, the pump should be slowed again to ensure the barrel does not overfill.

Filtration

Pumps are typically used to pass wine into a filter, except for filter units with an onboard electronic pump (such as a crossflow). The pump must have adequate speed control to adjust the flow rate to meet the changing demands of the filter media.

Bottling

Pumps are used to transfer finished wine from a vessel to a filling machine for bottling. The appropriate pump for this task largely dependent on the filling machine and its ability to interact with the pump. Diaphragm pumps are usually considered a good option for bottling, though rotary lobe pumps are also commonly used.

II. Common Pump Qualities

- **Minimize shearing and agitation of the wine** – Different pump mechanisms have different impacts on the wine.
- **Minimize exposure to oxygen** - Oxidation can be a serious issue for both must and wine. It is vital to have the ability to control oxygen ingress when performing these tasks.
- **Tolerant of sediment and solids** – Not all pumps are designed to transfer solids. If the goal is to transfer grapes or must, it is important to have the correct pump.
- **Speed control** – Direct speed control will allow the operator to perform the tasks discussed later in this section more precisely.
- **Self-priming** – Almost all new winery pumps are self-priming; however, some require more input than others.

- **Easy to clean and sanitize** – Cleaning is frequently required to maintain winery equipment properly.

- **Easily operated and maintained–** Operation should be simple and intuitive, especially in wineries where staff is required to switch between different styles of pumps.

III. Common Pump Styles[1]

Piston Pumps

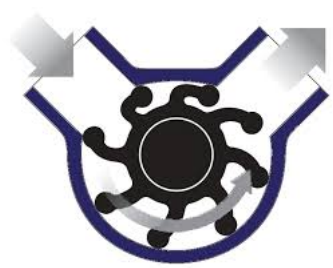
Piston pumps have a reciprocating or rotary piston alternately sucking in low-pressure fluid then compressing and discharging the fluid to a high-pressure area. They are self-priming and can provide variable flow rates efficiently with minimal shearing and agitation of the wine. Piston pumps are reasonably tolerant of solids and sediments and, since they are positive-displacement pumps, can deliver high pressures. One of the disadvantages of a piston pump is that the mechanical tolerances require maintenance to be done by trained personnel.

Moineau Pumps

Moineau pumps (AKA progressive cavity pumps or helical pumps) work by turning a winding rotor within a helix-shaped elastomeric stator. These complex shapes create fixed volumes that move along the rotor's axis to move fluid from one end of the pump to the other. These are self-priming positive-displacement pumps that minimize the shearing and agitation of the wine. They are highly tolerant of sediment and solids, easy to clean and maintain, and generally used for must. They can be very expensive but can work very well for large wineries with hundreds of thousands of gallons to move.

Peristaltic Pumps

Peristaltic pumps are popular for precision pumping applications that require an exact amount to be pumped. The pump works by turning a lobed shaft that progressively squeezes a soft tube filled with fluid, thus pushing the fluid out of the pump on the high-pressure side of the housing. A peristaltic pump is ideal for moving must and does well with wine. These are positive-displacement pumps that are self-priming and can deliver higher flow rates. They may also be run dry. If the pump runs after a tank is empty, the pump will not be damaged, though that should still be avoided if possible. These pumps tend to be large and awkward and can have trouble when running long distances or handling elevation gains.



Flexible Impeller

These are positive displacement pumps that can create moderately high pressures and can be used to pump liquids or gases. These pumps use a rubber impeller that flexes as an eccentric shaft turns within the pump body. These pumps are easy to clean and sanitize because there are fewer mechanical parts, making the pump more tolerant of sediment or suspended solids. They do not like to be run dry and can be rough on the wine, making them a sub-optimal choice for finished wine. However, they are ideal for pumpovers due to their flow rate, size, and portability. Depending on the pump's size, the impeller may be sensitive to hot water, and while they are self-priming, it is necessary to lubricate the impeller before use.

Diaphragm Pumps

Diaphragm (air) pumps work by contracting a rubber diaphragm to pull fluid into a chamber through an inlet valve, then expanding the diaphragm to push fluid out of the chamber through an outlet valve. This type of pump is inherently gentle while handling fluid, self-priming, simple, and relatively inexpensive. It is easy to change the flow rate of a diaphragm pump, and they are very portable. There is also no harm to run a diaphragm pump dry or with closed valves. On the downside, these pumps are not easily reversible, and require access to compressed air. Diaphragm pumps can also be difficult to properly sanitize due to the amount of moving parts that come in contact with the wine.

Gear and Rotary Lobe Pumps

Gear pumps work by moving fluid in the space outside of the gear teeth and sealing where the teeth mesh. A rotary lobe pump is a variation of a gear pump but uses a “gear” with rounded lobes instead of sharp teeth. They are good for moving wine because they are easily reversible, tolerant of some suspended solids, and efficient at high and low flow rates. Gear pumps are simple, durable, portable, and reliable. They are relatively cost-effective and easy to clean and sanitize.

Rotary Lobe pumps have all the advantages of gear pumps but are better at handling suspended solids and are slightly gentler with the fluid. Both gear pumps and rotary lobe pumps have finely machined tolerances that do wear out and may occasionally need servicing. A rotary lobe pump is often the workhorse pump of small to medium-sized wineries.

Conclusion

Matching form to function when it comes to wine pumps is often an ideal, not a standard. For those wineries without multiple pump options, recognizing the advantages and drawbacks of each can help aid decisions surrounding the when and how of moving grapes, juice, and wine.

Chapter 6: Tank Anatomy and Preparation

Introduction

Wine tanks are found in about as many variations of shape, size, and material as there are wines. Though there are thousands of models and styles of tanks, this chapter will attempt to categorize and describe some common attributes. Probably the most commonly used tanks are stainless steel and plastic. Concrete tanks have also made a resurgence in the last decade. While the setup of a specialized tank (concrete, wood, amphora, etc.) is similar to stainless steel and plastic, the preparation and cleaning step(s) before and after use are generally different, so it is best to follow the specific protocol used by the winery for these tanks.

I. Size

When considering which vessel to use, size is an essential consideration to ensure the requisite amount of room for expansion and foaming during fermentation and reducing surface area. Additionally, an idea of remaining grapes and processing space needed for future lots of wine is important to keep in mind. Tank management is a critical task of winemaking.

II. Style

Variable Capacity "VC"

These tanks have a lid whose height can be adjusted and then sealed by inflating a rubber gasket (Figure 6.1). The flexible height allows for reduced headspace, and therefore reduced risk of oxidation and microbial growth. However, the gasket must be monitored closely to ensure that it is inflated at all times and maintaining a proper seal. Additionally, the gasket and lid must be cleaned regularly, as this lid design can be conducive to bacterial growth.

Open Top Fermentation

An open-top fermentation tank will often have a "floating lid," as do variable capacity tanks. However, a fermentation tank is more than a type of VC tank. Rather, open-top fermentation tanks are unique in their shape and purpose. Since they are designed specifically for fermentation of whole or crushed berries, they typically have a larger circumference and shallower depth than storage tanks. This shape allows the "cap" to have more skin contact with the juice, thereby enhancing tannin and color extraction from skins. Additionally, a shallower cap allows for easier and more effective cap management. They will often have an open-top (with or without a lid) and can be semi-mobile to regulate temperature and clear winery space outside of harvest season. i.e., moveable with a forklift (Figure 6.2).

Closed Top

Closed top tanks have fewer moving parts and, therefore, fewer surfaces for potential microbes to live. Ideally, a closed top tank will be filled to its highest point (after fermentation) to reduce headspace. Since crop yields and press yields can vary, this is not always possible. It is important with any vessel to ensure any excess headspace is adequately protected with inert gas (Figure 6.1).

III. Vents

Most tanks have venting capacity. While it leaves finished wine susceptible to oxidation from ambient air, it allows for the expansion and contraction of wine volume as the temperature changes. In fermenting vessels, it will enable CO_2 to escape while maintaining a small amount of head pressure. Vents are usually located on the tank's lid, and they must be released during filling and emptying a tank.

IV. Valves

The two primary valves used in a winery are ball valves and butterfly valves. Both are quarter-turn (90-degree turn from fully opened to fully closed) rotary valves. They are used to control the flow of most types of gases or liquids across a wide range of temperatures and pressures. Butterfly and ball valves are both popular for their relatively low cost, long service life, and dependability. However, there are a few differences to help the user choose between them[1].

Ball Valves

A ball valve is (in simplest terms) a ball with a hole running through it. Turning the valve positions the hole to either block, partially block, or complete the flow line through the valve.

Advantages of ball valves include an excellent seal with little to no leaking when the valve is fully closed. A ball valve will turn regardless of the pressure on the supply side. If the hole through the valve is larger or larger than the supply pipe's inner diameter, the ball valve will essentially offer no pressure drop or restriction when fully opened.

Butterfly Valves

A butterfly valve is a disk mounted on a rotating shaft. When fully closed, the disk completely blocks the line. When fully opened, the disk is parallel to the flow of gas or liquid. One of the advantages of butterfly valves is that they are relatively inexpensive to build, clean, and maintain.

The butterfly valve disk is still in the valve flow line when fully open, so there will always be a pressure drop across a butterfly valve. Also, if the pressure difference across the butterfly valve is significant, it may be difficult to open the valve. Some applications require a bypass valve to bring the pressure difference down before large butterfly valves can operate.

Differences

Butterfly valves are less expensive and generally lighter weight than other types of valves. A butterfly valve for a large diameter pipe is much smaller than its ball valve equivalent.

Butterfly valves do not seal as completely as ball valves and are rarely used to control gas flows. Ball valves provide a reliable seal. In high-pressure applications, the ball valve will provide superior cut-off characteristics as well as having no trouble turning or needing a pressure-balancing scheme. Ball valves also offer the ability to insert mixers and racking tools into the tank, while butterfly valves do not. However, ball valves are more complex mechanically and are more challenging to clean.

Tasting Valve

Another common type of valve found in wineries is a tasting valve. While these valves may use several different mechanisms of action depending on the manufacturer, they all perform the same primary function: delivering samples of wine from a tank.

V. Doors

Though each tank is different, there are generally two types of doors that you will see on wine tanks: a racking door and a bottom door.

Bottom Door

As the name indicates, this is the door on the bottom of the tank. The bottom door is typically located at the lowest point of the tank and, for that reason, is primarily used when cleaning. Often there is an attachment at the same height, or just below, for the bottom valve.

Racking Door

Located above the bottom door is often the racking door. This door is used to access the wine so it can be racked off of gross lees or fining agents, rather than being pulled from the bottom valve and risking incorporating these components back into the wine. Similarly, there is often a valve attachment directly below the racking door known as the racking valve. Once the tank has been drained from the racking valve, the racking door should be able to open without spilling wine.

Each door will have a rubber gasket that allows the door to seal without leaking. The gasket is either built into the door itself or is removable. Removable gaskets must be installed, and doors positioned correctly before closure to ensure a proper seal.

VI. Cooling/Heating Jacket

Some tanks are equipped with “jackets,” meaning they have double walls that allow glycol or other coolants to circulate through them to control the fermentation and finished wine temperature. The ability to cool or heat necessitates a circulating pump, heating/cooling unit, and a jacketed tank. Depending on the size of the pump and heating/cooling unit, jacketed tanks may be connected in series or individually.

VII. Bins

Alternate fermentation vessels worth mentioning are MacroBins (Chapter 4). While this a brand name, it has become ubiquitous in the American wine industry in reference to a plastic bin. In other wine regions, alternate brands dominate, but almost everywhere is a comparable product. Often Macro bins (sizes 12, 16, 24, and 32) are used for harvesting or transporting harvested fruit. There are two other standard sizes (44 and 48) commonly used as fermentation vessels. A 44" MacroBin "T-Bins" will hold up to about 1 ton of destemmed grapes, and a 48" bin will hold about 1.5 tons of destemmed grapes.

VIII. Preparation

Preparing a tank for juice or wine has three basic steps:

a. Cleaning – Each winery will have a specific protocol on how to clean its tanks. It is important that tanks and all necessary accessories are clean both before and after use.

b. Attaching and closing valves – Appropriate valves and fitting should be attached at each location. It is important to ensure that they are all closed before filling the tank. Particular attention should be paid to tasting valves, which are often overlooked.

c. Venting the lid – Perhaps the most critical step is ensuring the tank is vented. As the tank fills with juice, the air inside of the tank is forced out. If the tank is not vented, it could break the tank, pump, or both. It is important to note that the reverse phenomenon is also true. When a sealed tank is emptied, it can potentially collapse in on itself like a dying galaxy.

Once these steps have been taken, hoses can be attached and the tank layered with inert gas.

IX. "Buttoning Up"

There are often a lot of tasks that need to be addressed at any given time in a winery. Especially late in the day. With the exception of emergent issues such as a leaking tank, turned-over forklift, or direct instructions from a supervisor, the most important task after filling a tank is making sure that it is "buttoned up" so that the wine is protected. Generally, this is accomplished with the following steps:

1. Take a dip. If there is no external volume gauge on the tank, measure from the top of the juice/wine to the tank's edge to determine the total volume. Do this first, so it is not necessary to un-do the lid and re-gas the tank.
2. Close the lid and gas the headspace of the tank with inert gas (Chapter 7).
3. Record necessary info per winery protocol (typically: wine, lot, date, volume).
4. Check tank temperature if applicable. If the tank has a thermostat, check to make sure the temperature is set appropriately. The temperature should have been set before/during

filling, but it is important to double-check. TEMPERATURE IS EVERYTHING (See Chapter 8).

5. Disconnect hoses and clean valves with water where this is visible dirt; follow with a sanitizing spray.

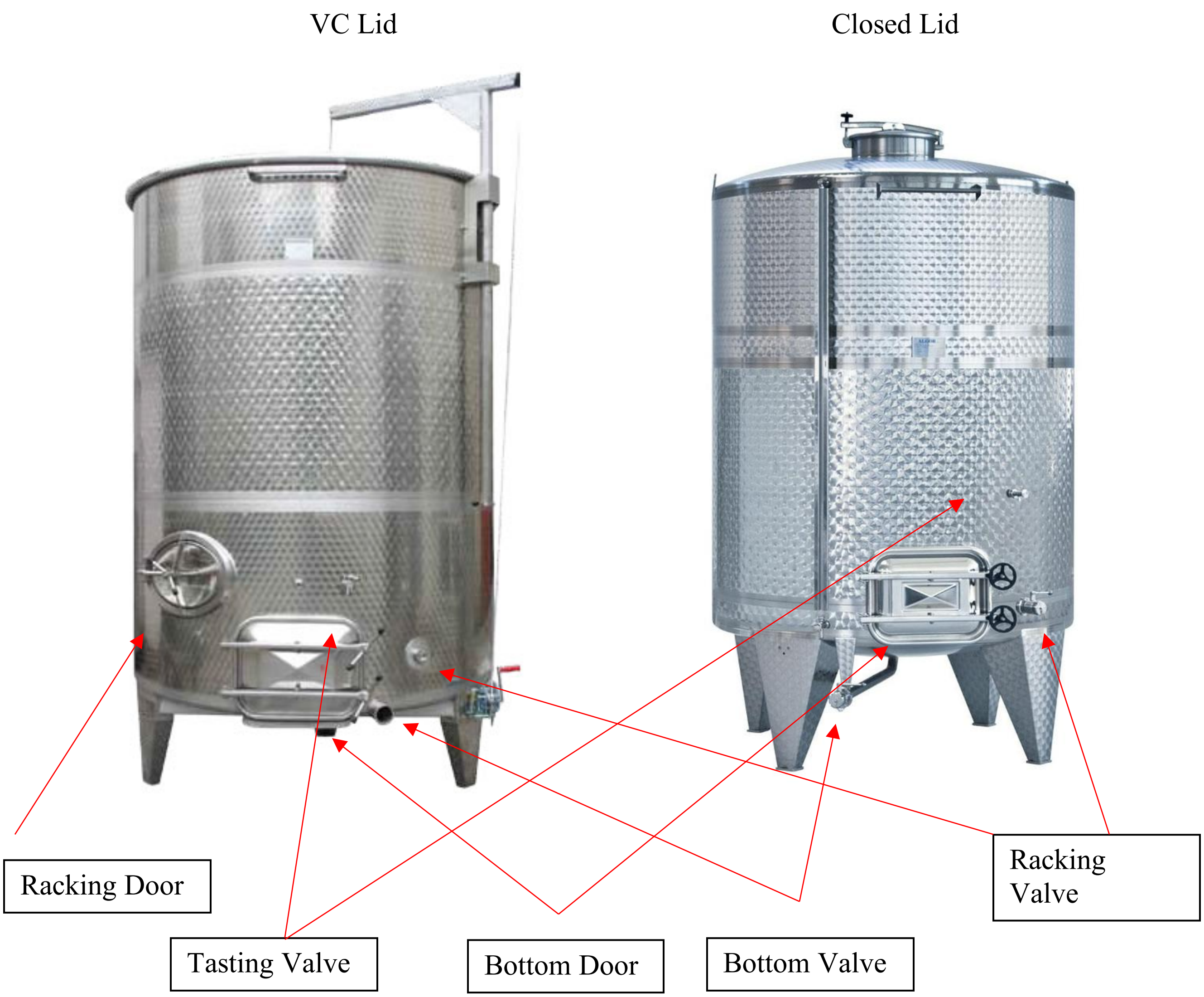


Figure 6.1- VC vs. Closed top tank and common tank features[2]

Figure 6.2 – Open Top Fermenter-shallow and wide for improved cap management and temperature homogenization[3]

Conclusion

The multitude of options available for tanks reflects the variety of consumer needs and by function winemaking styles. Knowing how tanks affect these styles and the dynamics of workflow can make cellar tasks that much easier.

Chapter 7: Gases

Introduction

Gases are extremely impactful on the winemaking process both as a variable to be managed and a tool to be utilized. With significant overlap, winery gases can generally be placed into two categories: Atmospheric and Commercial. Atmospheric gases are what we generally consider a threat to the quality of wine, primarily due to the presence of oxygen. While atmospheric air is comprised mainly of Nitrogen (78%), it also contains about 21% oxygen (Figure 7.1), which is the cause of "oxidation," a term repeated often.

I. Oxidation

By its strict definition, oxidation occurs when a compound loses an electron. The coupled opposite reaction (reduction) occurs when yet another compound receives that electron. Oxidizing agents (like oxygen or hydrogen peroxide) cause other compounds to lose electrons (oxidized). In contrast, reducing agents (SO_2, ascorbic acid, and phenols) can bind or react with oxygen to decrease the oxidation. In a more general sense, the term "oxidation" refers to the exposure of juice or wine to air. Oxidation can occur at any time during the winemaking process, starting as soon as grapes are removed from the vine. Some oxygen is beneficial to winemaking and fermentation. However, a little goes a long way, and too much oxygen can damage juice and wine.

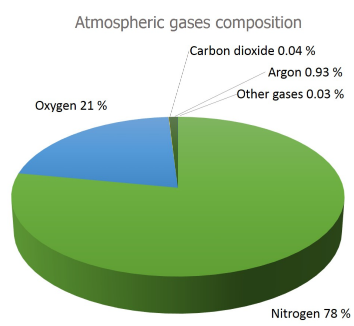


Figure 7.1 – Proportion of Atmospheric Gases[1]

The primary side effect of oxidation is the formation of acetaldehyde, a byproduct of ethanol's oxidation. A small amount of acetaldehyde can lend complexity to white wines and mouthfeel and structure to red wines. However, an excess of acetaldehyde can negatively affect any wine, causing a browning of color, loss of fruity varietal aroma, and the development of nutty and aldehydic aromas (like Sherry).

Oxygen dissolved in wine is also an important variable in the microbial spoilage of wine. Many yeast and bacteria that grow in wine require the presence of oxygen. Chief among these is acetobacter, a bacterium that will form a film on the surface of wine and produces acetic acid as a metabolic byproduct. Excess acetic acid lends a sour and vinegar taste to wines. Additionally, unwanted yeast such as Brettanomyces will thrive more easily in an oxygen-rich environment. These unwanted yeasts can lead to the formation of a "band-aid" or "horse blanket" aroma in wine.

However, despite the negative impacts of oxidation and dissolved oxygen, it is essential to note that a small amount of each is needed to make quality wine. Fermentation yeast require dissolved oxygen initially to create structurally sound cell walls. Additionally, the numerous chemical reactions taking place during the winemaking process rely on oxygen as a substrate. Therefore, the winemaker's goal is not to restrict oxygen entirely but to manage exposure to atmospheric gas throughout the winemaking process.

II. Management – Prevention

Cellar Technique

The most effective tool in managing oxidation is the proper handling and movement of juice and wine. Proper handling means adopting an efficient racking technique that avoids air uptake. Additionally, this means using the pump effectively to avoid pumping air into or, more importantly, through juice or wine.

Another important oxygen management technique is managing headspace. The goal of headspace management is to have the smallest possible ratio of air volume to liquid volume by limiting surface area. While we are not always able to perfectly match the volume of liquid to the volume of tanks or barrels, proper vessel management will help reduce headspace for each lot.

Inert gases (aka commercial gases)

If atmospheric gases are generally considered a threat to wine that must be managed, inert gases (commercial gases) counter that threat. Inert gases are a group of gases that do not undergo chemical reactions under standard conditions based on their molecular structure. Accordingly, they will not oxidize wine and instead can be used to protect wine from oxygen. Inert gases minimize oxygen pickup when used for blanketing, sparging, or transferring wine.

Blanketing – Inert gas can be used to "blanket" the headspace of a wine container. Inert gases that are heavier than atmospheric air (CO_2 and Argon) will displace the gas settled on top of the liquid and help prevent oxygen from reacting with it.

Sparging - Sparging is a technique used to remove dissolved gasses from a wine or fermentation sample by introducing a stream of very fine gas bubbles. The difference in partial pressures between the sparging gas and the dissolved gas (usually O_2) causes the dissolved gas to be pushed from the liquid into the headspace. Efficiency depends on many factors, including the physical properties of the gas bubble, size, contact time, temperature, pressure, flow rate, and equipment design (e.g., porosity)[2].

Transferring – It is important to displace oxygen from fittings, hoses, and tanks before transfers. Like blanketing a tank of wine, oxygen can be displaced from hoses, tanks, and barrels before transferring to avoid oxidation. When gassing equipment before a transfer, it is important to ensure valves are closed, the tank is properly vented, and connections have been made to guarantee efficient and effective gas use. Types of inert gases commonly used in the winery:

Common Gases

- Carbon Dioxide (CO_2): Heavier than oxygen, soluble in wine & cheap. Useful for blanketing wine.

- Nitrogen (N_2): Cheap, not soluble in wine & light. Useful to sparge a line or push a wine, not good for blanketing.

- Argon (Ar): Heavier than oxygen, not soluble in wine & expensive). Very effective for blanketing but often cost-prohibitive.

Sulfites

To combat the effects of oxidation, the use of sulfur dioxide (SO_2) is common. There are three species of sulfites in wine, though we often refer to them collectively as "sulfur dioxide." This terminology can be misleading since the different species play different roles. These species are pH-dependent, and at wine pH, the primary form is bisulfite (HSO_3^-) (Figure 7.2). Bisulfite, not SO_2, is responsible for combating oxidation. However, it will not bind oxygen directly; instead, it will bind oxidative precursors, preventing acetaldehyde formation. The sulfite species with the second-highest concentration at wine pH is sulfur dioxide (SO_2) gas; however, SO_2 is not considered an anti-oxidant but instead functions to control microbial populations through anti-microbial action (Chapter 3). The third species, sulfite, is not present in an appreciable concentration at a typical wine pH.

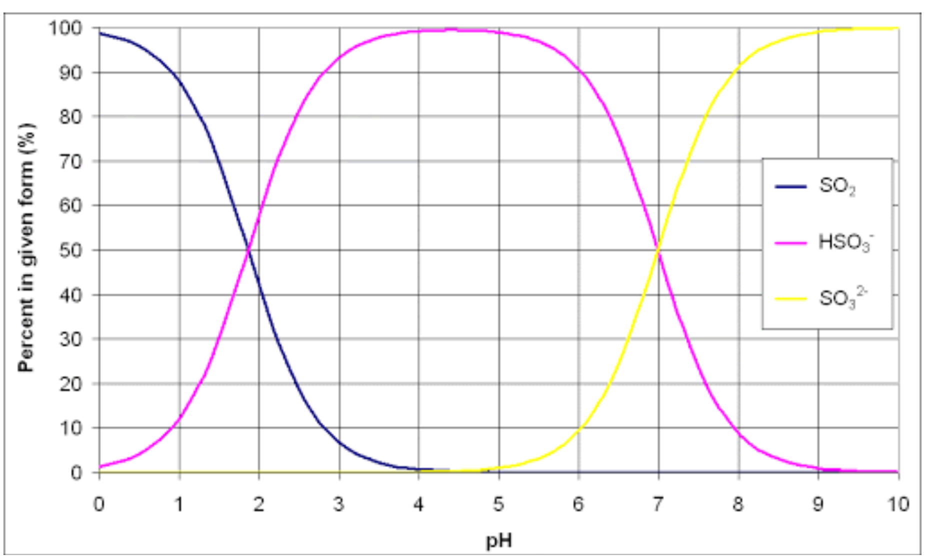


Figure 7.2 – Sulfite species vs. pH[3]

III. Management – Control

Sulfur Dioxide

In addition to bisulfite, sulfur dioxide serves a vital function in oxygen management. Sulfur dioxide is one of the sulfite species present when sulfur is added to the wine. Functionally, SO_2 helps control populations of yeast and bacteria but does not interact with oxygen or oxidative precursors. Sulfur, typically in the form of potassium metabisulfite, can be mixed with wine or water to create a solution, and the pH adjusted to increase the concentration of molecular SO_2 (Figure 7.2). Commercial SO_2 gas can be used to control microbial growth in empty vessels or to create an SO_2 solution for wine additions. However, it is extremely dangerous, and you should always follow OSHA guidelines and workplace standard operating procedures when handling it.

Ozone

Similar to SO_2, ozone gas can be used to treat winery equipment, helping to mitigate the effects of oxygen. However, like SO_2, ozone gas is extremely dangerous, and you should always follow OSHA guidelines and workplace standard operating procedures. Instead of being purchased as a commercial gas, ozone is typically generated on-site.

IV. Properties of Gases

Much like water, gases have several properties that make them physically and chemically unique. Many of these properties are what make them a valuable tool in the winemaking process.

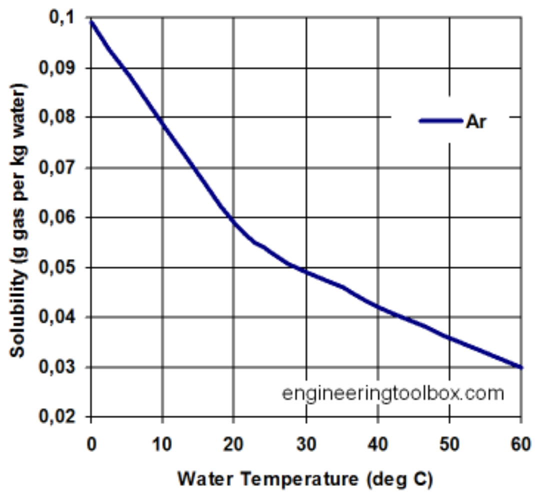
Stratification

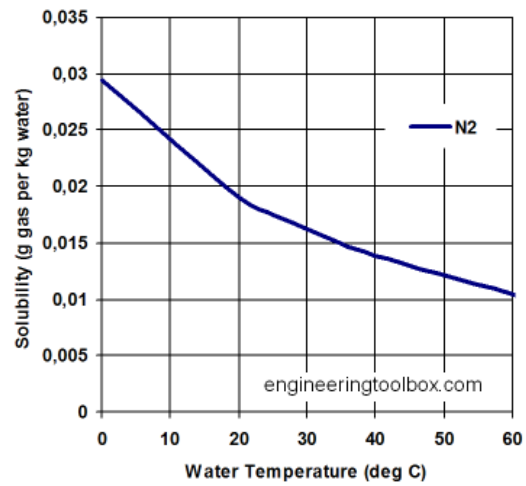
Gases expand to fill their containers, occupy far more space than the liquids or solids, and have a low density making them ideal for blanketing and filling the headspace of different vessels. Despite lower densities compared to solids and liquids, gases of different densities will still stratify. Stratification is the extent to which the heavier gases tend to settle to the bottom and the lighter gases rise to the top of an initially uniform air mixture. Heavier gases like carbon dioxide will settle in low-lying areas (think water poured in a bowl), displacing lighter gases like oxygen. This concept also raises an important safety consideration since CO_2 can also "settle" in the lungs, causing suffocation.

Carbon dioxide produced by fermentation in a winery building must be ventilated to ensure that it does not settle and displace breathable air. In a CO_2 rich environment (i.e., wineries during fermentation, or digging out a fermentation tank), workers can find themselves breathing too much carbon dioxide. Unfortunately, many people die every year due to asphyxiation in wineries. Because of the grave safety risk posed by CO_2, it is essential to use CO_2 monitors and follow workplace standard operating procedures to prevent injury, particularly during active fermentations or digging out fermenters.

Solubility

When considering the effects of atmospheric gases and the utilization of commercial gases, solubility is an important variable. Regardless of reactivity, gases have varying tendencies to enter into a solution with wine (i.e., become a dissolved gas). This tendency is altered with both pressure and temperature (Figure 7.3). Generally, as a solution gets warmer, the solubility of gasses decreases. Accordingly, as wine gets colder, gas is more soluble in the wine. For example, racking or transferring wine after cold stabilization, is likely to cause an increase of dissolved oxygen in the wine. While temperature is not often used as a direct means of oxygen management, it is an important variable in determining when wines are most at risk. Proper cellar techniques and the use of inert gases become increasingly relevant as the temperature of wine decreases.





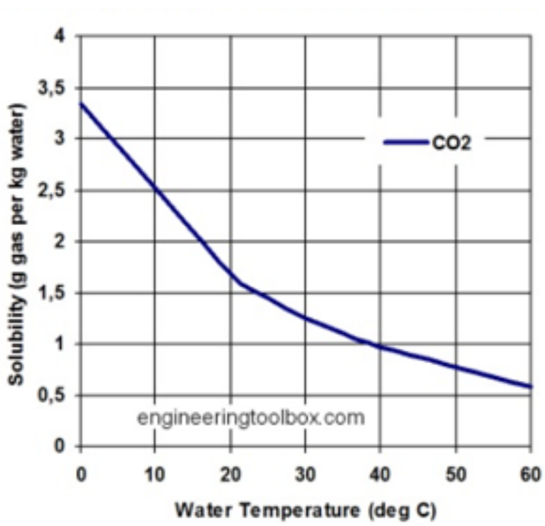


Figure 7.3 – Solubility vs. Temperature of common winery gases[4]. Argon (Ar), Nitrogen (N_2), and Carbon Dioxide (CO_2)

V. Gas cylinder safety

In addition to the dangers of commercial gases mentioned above, there are specific safety concerns surrounding how commercial gases are transported and delivered. Gases are packaged in cylinders capable of withstanding high temperatures and pressures, allowing manufacturers to package a lot of gas in a small space. Cylinders come in various shapes and sizes depending on the winery's needs and the specific gas (Figure 7.4). The gas is accessed from the cylinder by attaching a gas regulator to the top valve. Without a regulator, cylinders are equipped with a cap to protect the valve at the top.

Because of their awkward shape, cylinders are incredibly likely to fall over. Since they are also typically very heavy, this presents a safety hazard for someone close to the cylinder. Beyond a simple falling hazard, because gas cylinders are pressurized, if the top valve is broken during a fall, it could result in the cylinder's instantaneous depressurization, causing it to move randomly at a high velocity. This is a danger to everyone in the winery.

To prevent a catastrophic failure of a cylinder upon falling, it is important that gas cylinders are treated carefully and always attached to a stationary object. When not in use, cylinders can be attached to a wall or upright support. When being used around the winery, they should be attached to a mobile gas cart. These carts are designed to stabilize gas cylinders while also letting the user move them from place to place. Additionally, when moving or replacing a gas cylinder, the cap should always be secured over the top valve and not removed until the cylinder is attached to a stationary object. Please use OSHA guidance (link in "More Information") and follow workplace standard operating procedures when handling gases.

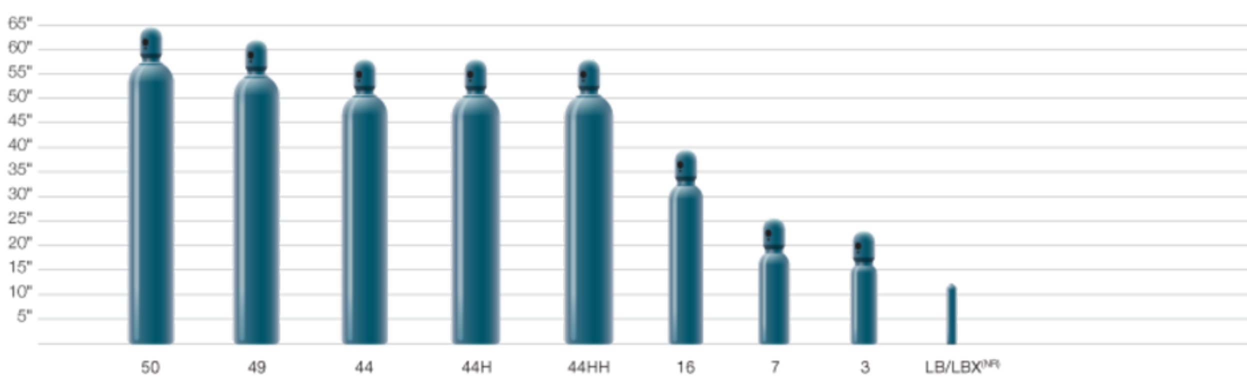


Figure 7.4 – Sizes and names of common gas cylinders[5]

VI. Ideal Gas Law

No discussion of a gas, practical or otherwise, would be complete without mentioning the ideal gas law. This law describes the behavior of ideal gasses, which includes the gases encountered in a winery.

Ideal Gas Law: $PV=nRT$

where P is pressure (atm), V is Volume (L), n is the number of gas particles (moles), R is a constant (0.082057 L atm $mol^{-1}K^{-1}$), and T is the temperature (K).

The principles and characteristics described here can be seen in real numbers. For example, with lower temperature and increased pressure, the volume of gas decreases while maintaining the same total number of molecules. This explains why cylinders of gas in a winery can deliver a much greater volume of gas compared to the volume of the cylinder. For more applications of the ideal gas law, please see the link below.

Conclusion

Using gas in a winery is common, complex, and, when done poorly, dangerous. Understanding how to work with and against different gases simultaneously, effectively, and safely is vital for making quality wine.

More Information:

Use of Inert Gases - Murli Dharmadhikari Iowa State University
https://www.extension.iastate.edu/wine/use-inert-gases

OSHA: https://www.osha.gov/SLTC/compressedgasequipment/index.html

Kahn Academy: Using the Ideal gas law
https://www.khanacademy.org/science/ap-chemistry-beta/x2eef969c74e0d802:intermolecular-forces-and-properties/x2eef969c74e0d802:ideal-gas-law/v/worked-example-using-the-ideal-gas-law-to-calculate-number-of-moles

Chapter 8: Temperature

Introduction

Every stage of winemaking is, in some way, impacted or influenced by temperature. From fruit handling to fermentation, aging, bottling, and bottle storage, the temperature must be considered each step of the way. However, much like winemaking techniques, there is no single optimal temperature during any of these phases. Learning how temperature impacts the finished product is an important tool for determining how to use temperature to achieve winemaking goals.

I. Fruit Processing

Common Range: 32 to 40°F
0 to 4°C

With the exception of cooler climate vineyards or harvesting at night (when temperatures are generally a little cooler) most fruit should be chilled as soon as possible after harvest and remain cold until processing. Cold fruit can limit the growth of most microbes as well as slow oxidative deterioration. If the goal is to cold settle the juice or cold soak the fruit before fermentation, chilling the fruit first will also help the juice or must get to the lower temperatures needed to achieve either goal. However, depending on a winery's layout and resources, cooling capacity may be limited. Regardless, the fruit should be as cold as the facility allows without risking damage by freezing.

As discussed in Chapter 2, warmer fruit will also lead to warmer juice initially. Fermentation may start before intended due to yeast on incoming fruit. This could cause issues if the intent were to cold settle the juice to reduce solids before fermentation. Additionally, pressing warm fruit can lead to higher succinic acid concentrations resulting in increased bitterness of the finished wines[1]. While chilling fruit is recommended for many reasons, if fruit quality is significantly poor or compromised, it might make more sense to process the fruit immediately to ensure microbial stability.

II. Juice Settling

Common Range: 30 to 32°F
-1 to 0°C

White and Rosé juice is often settled before the start of fermentation to reduce the concentration of solids. Juice settling is often aided by either addition of bentonite or enzymes. The biological action of enzymes is greatly influenced by temperature. Reaction rates are generally increased as temperatures increase and can be inhibited by cold temperatures. Pectolytic enzymes in white and Rosé juices can allow for better settling, but it is important to understand the recommended temperature range for the particular product being used. The combination of cold settling and enzyme use might mean that the enzyme is only active for a short time before the juice decreases to a temperature where the enzyme is no longer effective. However, colder temperatures also promote settling, so a balance must be reached. Of note, the efficacy of bentonite is not as temperature-dependent as enzymes. However, it is important to use the appropriate temperature water when rehydrating. If the solution is not warm enough or given the proper amount of time to swell, it will not be as effective once added to the juice.

III. Cold Soak

Common Range: < 50°F
< 10°C

Some winemakers employ a technique known as "cold soak" before fermentation, where processed fruit is stored at cold temperatures in a tank or bin. This technique can be applied to either red or white grapes, depending on the varietal and desired wine style. Though the temperature range varies considerably based on winemaker preference and the winery's cooling capacity, the suggested temperatures are typically below 10 °C or 50°F. This temperature allows for the cold soak's potential attributes to be effective but is cold enough to prevent the growth of unwanted yeast and bacteria. Following the cold soak, attention must be paid to how quickly the must temperature increases. A delay of more than a few days can lead to an increased potential of spoilage yeast or bacteria.

IV. Fermentation

Common Range: Red Wine: 70-85°F
21-30°C

White Wine: 50-65°F
10-18°C

Fermentation and its associated variables are discussed further in Chapter 9, but the role of temperature during fermentation cannot be overstated. Higher and lower temperatures have both advantages and disadvantages and can help define a specific wine style. Generally, red wines are fermented in a higher temperature range 70-85°F (21-30°C) compared to white wines 50-65°F (7-15°C). Beyond stylistic goals, fermentation temperatures vary heavily based on yeast choice and vessel type.

Stylistic Goals

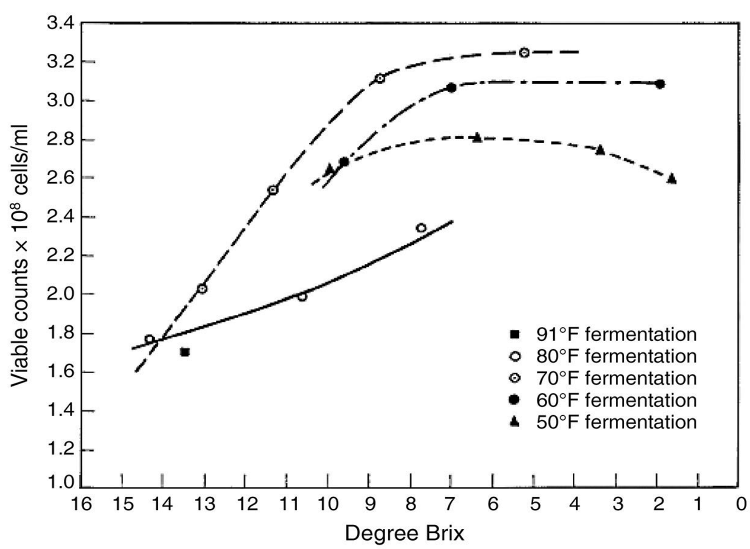
Fermentation temperature impacts the volatile compounds produced during fermentation. Higher concentrations of esters are generally found in wines produced at lower fermentation temperatures, likely due to lower volatilization and decreased chemical breakdown of the esters, but this is not always the case[2,3,4]. Temperature also impacts the biochemical pathways of the cell, which can influence aroma development[4,5]. Many volatile compounds seem to be produced during the exponential growth phase except for acetate esters, produced chiefly during the stationary phase[4]. Additionally, different kinds of volatile compounds are favored at different temperatures, with one study showing that more "flowery" components were favored at 28°C. In contrast, more fresh and fruity elements were favored at 15°C.

Volatile thiols, such as those present in Viognier and Sauvignon Blanc, are also impacted by fermentation temperature. One study found that 3-mercaptohexanol and 3-mercaptohexyl acetate were increased in Sauvignon blanc wines produced at 20°C compared to 13°C[6]. Due to the impact of yeast growing phase and temperature on these products, and the effect of higher temperature on the potential volatilization and chemical degradation of esters, it is hypothesized that fermenting juice at a higher temperature during the growth phase followed by cooling the juice to lower temperatures may allow for increased thiol production and volatile retention.

Yeast Viability

In general, it is accepted that lower temperature white and Rosé fermentations will result in aromatic preservation and that higher fermentation temperatures in red must results in higher polymeric pigment and phenolic extraction. However, there is a balance between yeast health, extraction optimization, and stylistic goals. The impacts of temperature on fermentation can depend on the strain of yeast carrying out that fermentation. Many commercial yeast strains have a referenceable optimum temperature range for fermentation.

While the yeast *Saccharomyces cerevisiae's* optimum growth temperature is around 28°C, the heat produced by fermentation is sufficient to raise the temperature of the grape must to more than 40°C[2,7]. At this temperature, yeast viability is reduced, and the generation of undesirable flavors can result (Figure 8.1)[2].



Plot of viable cell counts (x 10^8/ml) versus °Brix for Pinot blanc juice from grapes picked at Davis, at several temperatures of fermentation.

Figure 8.1 – Fermentation rates vs. Temperature[8]

Vessel Type

The type of vessel used for fermentation will have a significant impact on the temperature. Vessels are available in many shapes, sizes, and materials. Each of these variables will significantly impact the vessel's capacity for convective heat loss (i.e., passive heat loss). Heat loss can be both desirable or undesirable depending on the specific fermentation. Other vessels are equipped with active temperature control measures (heating and cooling).

Material – Vessels are commonly made from stainless steel, plastic, clay, concrete, and wood. Each of these has different insulating properties, allowing the fermentation to be cooled by ambient air. Stainless steel is generally considered to hold in the least amount of heat among available materials.

Size/Shape - Similar to material, vessel size and shape will have a significant impact on convective heat loss. Broader and shallower vessels will allow for the most heat loss given the low depth and increased surface area. As the ratio of tank height to width increases, the size of the heat sink increases, and the opportunity for passive heat loss decreases.

Control – Many vessels are equipped with the ability to perform active cooling. Active cooling is typically accomplished with built-in tank jackets that circulate cooled glycol (Chapter 5). Other options include submersible coolers, also circulated with glycol, of various shapes and sizes. These are especially useful for vessels that are not equipped with integrated cooling. Barrels and other such containers can also be moved to areas of the winery to use a different ambient temperature (i.e., under a heater or in a temperature-controlled cold room or barrel room).

V. Cap Management

An essential function of cap management is to equalize the temperature at different parts of the vessel. Heat accelerates the enzymatic break down of cell walls, loosens cell membranes, makes them more permeable, and increases diffusion rates of chemicals in liquid, all of which contribute to greater extraction of compounds from fermenting grapes. Cap management helps to homogenize a fermentation vessel's temperature, allowing for more accurate data with which to make temperature management decisions. In addition, it helps prevent under or over-extraction of specific areas within a vessel. Cap management techniques, frequency, and duration can all be altered to affect temperature.

VI. Finished Wine – Aging

Common Range:	Red Wine: 57-60°F 14-16°C
	White Wine: 50-55°F 10-13°C

Because chemical reactions continue to take place as wine ages, it remains true that the temperature of the wine should neither be too warm or too cold. There must be a balance in the idea of optimum temperature so that desired reactions, such as tannin polymerization, are allowed to proceed and less desired reactions, such as bacterial growth, are slowed down. In general, these reactions will happen at a faster rate at a higher temperature. It is estimated that a reaction occurs at twice the rate for each increase in temperature of 10°C. This can mean an accelerated rate of both oxidation and microbial growth.

Oxidation

As discussed in Chapter 7, when temperature increases, gas solubility decreases. However, during storage, wine still contains dissolved oxygen and may be intermittently exposed to the atmosphere at its surface or during transferring, racking, or other manipulation. Temperature impacts the rate of oxidation reactions, including those that eventually contribute to the deterioration of wine (i.e., the conversion of alcohol to acetaldehyde). However, cooler temperatures do not entirely prevent oxidation reactions from occurring; they are simply slowed down. Similarly, microbial spoilage is also encouraged by higher temperatures but inhibited by lower temperatures.

Microbial Growth

The proliferation of *Brettanomyces*, a common spoilage yeast, is significantly impacted by temperature. Temperature increases of 2 to 6°C make volatile phenols appear both earlier and faster, regardless of the wine or the yeast strain present. Accordingly, spring is a potentially vulnerable time for wines as the cellar warms, and some red wines may not have adequate SO_2 protection yet. Other yeasts and bacteria's growth rates are affected similarly by temperature, helping single microbes form colonies and eventually spoil the wine.

VII. Finished Wine - Bottled

Common Range: 55°F (13°C)

The same ideas that apply to aging bulk wine apply to aging bottled wine. Bottled wines still contain dissolved oxygen and experience some amount of gas exchange through their seal (cork, cap, etc.). It is also important to note that fluctuations in temperature change a bottle’s pressure, which can cause wine seepage or oxygen ingress.

Finished wines may also be threatened by the onset of a haze created by heat instable proteins. While this can occur in any finished wine, it is of particular note in bottled wine because it is hard to remove once in a bottle. As temperature increases above 95°F (35°C), proteins in a solution with the wine will begin to denature and “unfold,” causing a haze to form in the wine. This effect is routinely muted or eliminated pre-bottling using bentonite fining or filtration.

VIII. Temperature based techniques

Beyond the scope of temperature management throughout the process, there are a handful of winemaking techniques that specifically use extreme temperatures to accomplish a task. Two common examples of this are cold stabilization and flash detente.

Cold Stabilization

Cold stabilization is a common technique that is designed to prevent crystals of potassium bitartrate (KHT) from precipitating out of the wine after it is bottled. Though the crystals are harmless, they are commonly thought to detract from the commercial viability of a wine. Freezing temperatures (20 to 30°F or -2 to -6°C) will reduce the solubility of KHT, which will then begin to form crystals on the surfaces of the cooling vessel. Once an appropriate amount of crystallization has occurred (several days), the wine is racked or filtered to a separate tank.

Flash Détente

This technique is commonly found only at larger wineries, given the significant capital expense. It can improve the quality of under-ripe or rotten grapes by a process that is essentially pasteurization. Crushed grapes are heated to approximately 185°F (85°C) and quickly cooled. Flash détente often concentrates flavors, extracts additional color, and releases volatile compounds.

Conclusion

Temperature is a critical aspect of winemaking, perhaps tantamount only to cleaning. However, unlike cleaning in many situations, the temperature is more difficult to control. Temperature control relies on many external factors, including weather, climate, electrical power, equipment, and space. Navigating these variables during harvest often becomes as important of a function to winemaking as fermentation itself…

Chapter 9: Fermentation

Part 1 – Alcoholic Fermentation

I. What is Fermentation?

Fermentation is the biological production of energy in the absence of oxygen. The byproducts of fermentation depend on the specific organism in action. Many of the foods we enjoy are produced with fermentation from various microbes: cheese, pickles, vinegar, kimchi, beer, etc. Alcoholic fermentation of glucose and fructose by yeast in grape juice results in the production of ethanol and carbon dioxide (CO_2), ultimately resulting in wine. For every single molecule of sugar, yeast will produce two molecules of ethanol and two molecules of CO_2. This balanced fermentation equation (Figure 9.1) is important for calculating potential alcohol (Appendix IV).

$$\text{glucose} \xrightarrow{\text{yeast}} \text{ethanol} + \text{carbon dioxide}$$

$$C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2C_2H_5OH_{(aq)} + 2CO_{2(aq)}$$

Figure 9.1 - Balanced Fermentation Equation[1]

II. Yeast and Inoculation

Commercial yeasts for winemaking are commonly of the genus/species *Saccharomyces cerevisiae* (*s.c.*). *Saccharomyces* has come to be a preferential wine fermentation yeast for the following reasons:

- Preferential for alcoholic fermentation.
- Works well at wine pH and acidity.
- Works well at wine fermentation temperatures.
- Resistant to higher alcohols.
- Will sometimes outcompete other microbes.
- Widely available.

Beyond *s.c.*, *Saccharomyces* of other species (bayanus) are also common. Additionally, “non-sacch” yeast and indigenous yeast cultured from the winery or vineyard are enjoying a modern-day resurgence. Though often used interchangeably with “spontaneous fermentation”, a “natural fermentation” implies that indigenous yeast culture is created and then used to inoculate grapes. On the other hand, spontaneous fermentation suggests that the grapes are simply left open to the air, and eventually, enough yeast will collect and reproduce. Indigenous yeast fermentations resulting from either of these methods are often associated with the following advantages and disadvantages:

- Generally, more susceptible to off odors, typically ethyl acetate (nail polish) and acetic acid (vinegar).
- It can be challenging to complete fermentation on high Brix fruit.
- It can be very cost-effective as well as adding unique character to the wine.

Inoculation is a term that refers to adding a yeast culture to grape juice to start fermentation. There are three common inoculation methods: preparing commercial yeast, preparing indigenous yeast, and adding a portion of currently fermenting juice to unfermented juice. The ultimate goal of each is to obtain a high (but healthy) population to kick off the fermentation. Generally, this means a population of 1×10^6 cells/mL (1,000,000 cells/mL). For white wines, this inoculum is typically added to the juice and for red wines directly to the juice/berry mixture.

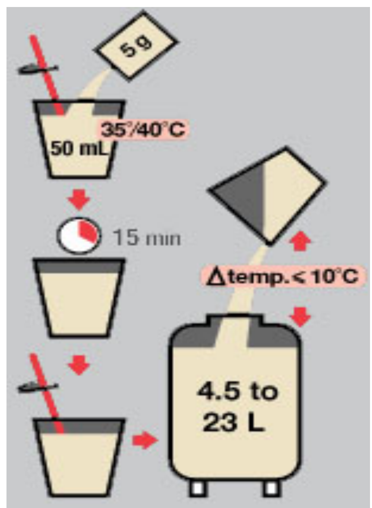


Figure 9.2 – A common yeast Rehydration sample protocol[2]

III. Monitoring Fermentation

Once the juice or must is inoculated, the fermentation will need to be observed and recorded. Monitoring is accomplished by measuring the sugar content and temperature of the fermentation periodically. Typically, this is done every day; however, specific protocols and methods vary from winery to winery.

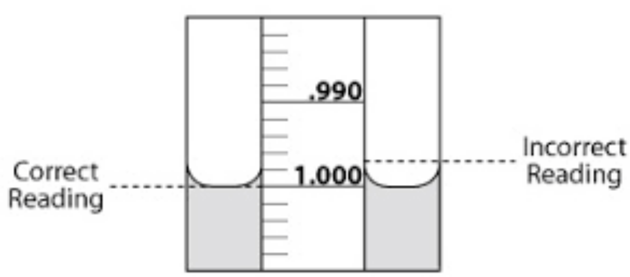


Figure 9.3 – The correct method for reading a hydrometer. A hydrometer is tool used for measuring the density of liquids and one of several methods used for evaluating the sugar content of fermenting must[3].

The life of a fermentation will typically have four distinct phases: lag, log (growth), stationary, and decline (death) (Figure 9.4). By measuring sugar and temperature, the fermentation can be illustrated in what is known as a fermentation curve (Figure 9.5). The fermentation curve can show if the fermentation is healthy (i.e., in the correct temperature range and supplied with nutrients) and is likely to finish, completely converting sugar to alcohol and CO_2.

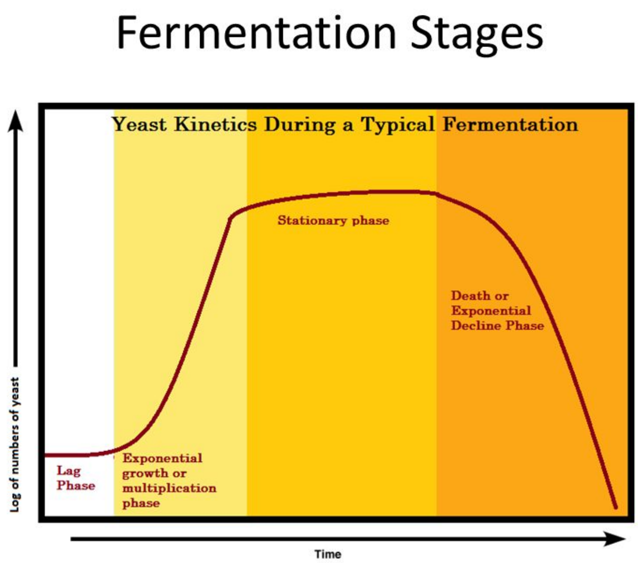


Figure 9.4 – The four phases of fermentation[4]

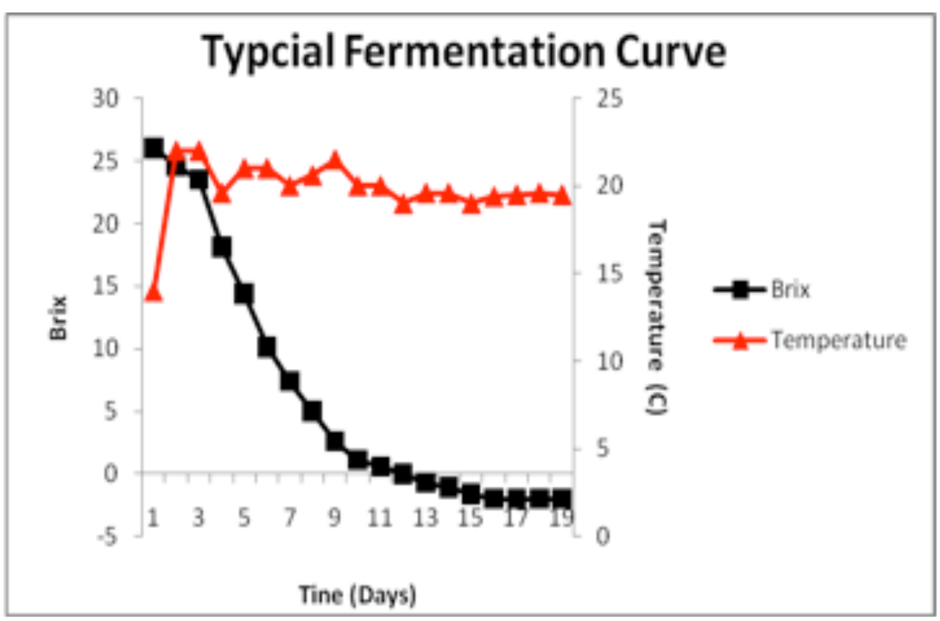


Figure 9.5 – A typical fermentation curve tracking sugar concentration and temperature[5]

IV. Temperature

As discussed in Chapter 8, the correct temperature range for fermentation is important for several reasons. Both high and low temperatures have advantages and disadvantages that can be used to help define a specific wine style. Generally, red wines are fermented in a higher temperature range 70-85°F (21-30°C) as compared to white wines 45-60°F (7-15°C).

High temp

- Drives off volatile aromatics
- Increases ethanol
- Denatures essential proteins and enzymes
- Significant impact on yeast cell division.
- Can lead to a "runaway fermentation"
- Increases color extraction
- Increases tannin extraction

Low temp

- Slows/stops fermentation
- Reduces extraction of grape components
- Reduces volatilization
- Preserves volatile aromatics
- Minimizes VA
- Enhances mouthfeel (i.e., volume)

It is important to remember that during fermentation, there are two temperatures to consider. Both the temperature of the juice or must and also the temperature increase caused by energy production of the fermentation itself which yields heat energy as a byproduct. The heat released by yeast is estimated to be approximately 23.5kcal/mol glucose which equates to about 1.3°C per 100g of sugar. Constant production of heat can lead to the temperature "stratification" of the fermentation vessel. The temperature throughout the vessel must be as homogenous as possible.

V. Nutrients

Nutrients for yeast exist primarily in the form of nitrogen. Yeast needs nitrogen to reproduce and build protein, much like people. Nitrogen concentrations relevant to fermentation are typically referred to collectively as Yeast Assimilable Nitrogen, or "YAN." This is the nitrogen available for the yeast to consume and is comprised of free amino acids, ammonia, and ammonium. A YAN concentration of 150-250 mg/L is generally accepted as appropriate; however, a significant amount of debate surrounds this range. Grape must can be supplemented with nutrients to increase YAN or diluted with other musts to reduce YAN. Ideally, any adjustments to YAN are accomplished through farming practices. If not, low YAN can be adjusted within 24-48 hours of inoculation and supplemented during the first 1/3 of fermentation. Adjustments are often made with the addition of a fermentation nutrient, of which there are several versions commercially available.

Other Common Additions

A vast number of variables will determine if it is appropriate to make other additions to a fermentation. These are a few commonly added products:

Water – Can be added to reduce final alcohol concentration. In many areas, water addition is only legal on must, not finished wine, so additions must be made early.

Sugar – Can be added to increase total alcohol, sweetness, or both. Typically, additions are made after fermentation has begun.

Acid – Can be added to affect the acid profile. Will increase TA and lower pH. The most common is tartaric acid, but different acids will have different characters and change TA and pH uniquely. If significant acid additions are needed, they should occur early in the winemaking process for better integration into the final wine.

VII. Off Odors

In addition to measuring sugar and temperature frequently, everyone in the winery should be aware of any "off odors" emanating from a fermentation tank (or any tank). Off odors are a telltale sign of an "unhappy" ferment and usually indicate either microbial spoilage or a stressed yeast population. Typical fermentation off odors to be aware of include:

Ethyl acetate (EA) – Nail polish remover – Typically a result of non-sacch yeast; extremely volatile, can blow off at higher temps

Hydrogen sulfide (H_2S) – Rotten eggs – Typically a result of yeast stress. Stress can be caused by underfeeding, overfeeding, or incorrect temps

Mercaptans – Rotten eggs, garlic, onions, cabbage - Hydrogen sulfide reacts with other wine components (ethanol, oxygen, etc.)

VIII. Cap Management

As a fermentation containing whole/crushed berries or clusters (typically red wine) begins to produce CO_2, this will cause the berries to float to the top of the fermentation vessel forming a "cap." It is crucial to redistribute this cap to prevent berries from drying out, homogenize the fermentation temperature, and increase skin tannin extraction. Though there are many approaches to cap management, two common industry practices are punchdowns and pumpovers (Chapter 2). Their actions mimic their names (Figure 9.6), but each can vary in frequency and duration according to the winemaker's preference.

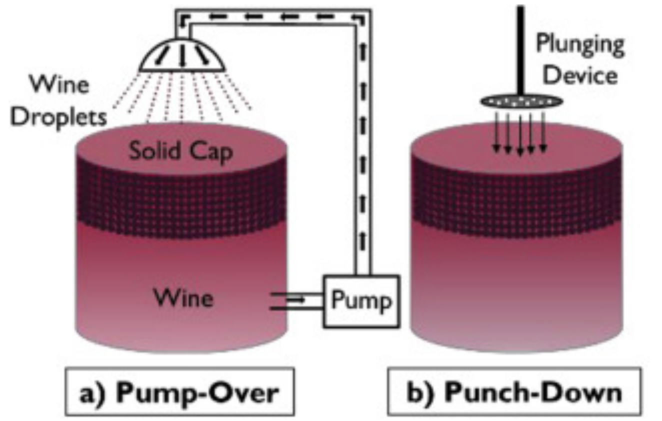


Figure 9.6 – Punchdown vs. Pumpover, two common cap management techniques[5]

IX. Sluggish and Stuck Fermentations

Occasionally, a fermentation will cease prematurely. Stuck fermentations can occur for a variety of reasons, though commonly, it is due to insufficient yeast nutrition, inappropriate temperature, or accidental additions. Sluggish fermentations can typically be finished by correcting the misaligned variable. Stuck fermentations are often harder to remedy, requiring the re-start of fermentation under less than ideal conditions for yeast (high alcohol, low nutrient, low sugar). Restart protocols vary but are typically labor-intensive, so prevention is typically best.

X. Extended Maceration (Typically Reds)

Extended maceration refers to the time after fermentation is complete, but maceration continues. This added time is designed to increase the extraction of color and tannin. However, extended maceration also increases the risk of microbial instability and oxidation. The cap will have "sunk," but very gentle punch downs or mixing should be performed daily and the vessel layered with an inert gas after. Additionally, it is essential to keep the vessel covered and avoid fruit fly exposure, a common vector for bacteria.

XI. End of Fermentation

When is Fermentation Complete?

<u>Technical Answer</u>: When all of the sugar is gone (aka Dry). **Note:** this does not correlate to 0 Brix. Because the density of alcohol is less than that of water, a finished fermentation will have negative Brix or a specific gravity of less than 1.

Acceptable: 0.5g/L*
More acceptable: 0.3g/L
Very acceptable: 0.1g/L
(*grams/Liter and % are NOT the same. They differ by a factor of 10. If there is 1% residual sugar, there is 10g/L of sugar)

<u>Actual Answer</u>: Whenever you want it to be

Fermentation can be ended at any sugar concentration the winemaker wants. Some prefer to make all wines dry and then add sugar back as desired. This approach gives more control but requires more work/time and is not always legal. Alternatively, fermentation can be stopped prior to dryness, leaving the desired sugar concentration remaining in the wine. To confirm that a wine has completed fermentation, it is common practice to measure residual sugar concentration. Testing methods include a rapid assay performed in the winery or a more specific enzymatic assay performed in a lab.

There are several ways to stop fermentation, though commonly, winemakers will use a bolus of sulfur dioxide. Other methods include chilling, enzymes, and filtration. Even with complete dryness, ending the fermentation ensures that yeast and other microbes do not proliferate on a small scale, potentially leading to spoilage. However, if malolactic fermentation is desired, then no halting action should be taken.

Part 2 – Malolactic Fermentation

Malolactic fermentation (MLF) is the conversion of malic acid to lactic acid by bacteria to create biological energy. This process is carried out by a class of bacteria known as malolactic bacteria (MLB) or sometimes lactic acid bacteria (LAB). Malolactic fermentation is also known as "natural deacidification." This moniker originates from the idea that malic acid is being de-carboxylated, or essentially weakened, for its conversion to lactic acid. Besides lactic acid, carbon dioxide is also a byproduct of MLF, as shown in the balanced equation in Figure 9.7 below.

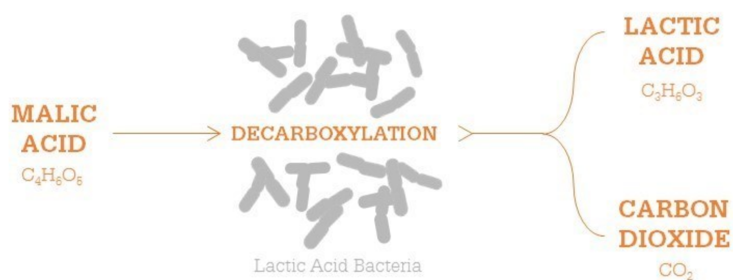


Figure 9.7- Malic acid is converted to lactic acid and carbon dioxide by malolactic bacteria[6]

I. Bacteria and Inoculation

Malolactic fermentation can occur before, during, or after alcoholic fermentation. However, they typically will not proceed concurrently unless by design (i.e., the ferment is inoculated with MLB). This is referred to as "co-inoculation" and recently has become a more popular approach to MLF, though the industry standard currently remains "sequential inoculation." Sequential inoculation is when the wine is inoculated with MLB or spontaneously begins MLF after alcoholic fermentation is complete. For many reds and some select whites, this typically occurs once the wine has been "barreled down" following pressing (see Chapter 10).

Similar to yeast, there will be indigenous MLB both in the vineyard and winery capable of carrying out this fermentation. However, many winemakers choose to inoculate with specific

MLB strains (commonly *Oenococcus onei*) to control potential wine faults and off odors. Various MLB strains, including *Leuconostoc, Pediococcus*, and *Lactobacillus*, are associated with these faults/odors. Additionally, MLB can produce diacetyl, the compound associated with some wines' "buttery" flavor. The production of diacetyl is strain-dependent and can be controlled with commercial bacteria selection

II. Monitoring Fermentation (MLF)

Malolactic fermentation is not monitored as frequently or by the same methods as alcoholic fermentation. If a complete fermentation is desired, monitoring can be less frequent and used simply to verify malic acid's absence. If a partial fermentation is required, a quantitative measure of malic acid is needed. Sensory testing is frequently used to verify fermentation. Wine in the process of MLF will typically have a "yogurt" smell and make a crackling sound similar to Rice Krispies cereal.

III. Temperature (MLF)

As the wine temperature increases, so too does the rate of MLF. However, at this stage, the fermented wine is also more susceptible to microbial instability from higher temperatures. Accordingly, MLF is usually carried out at around room temperature (20°C).

IV. Nutrients (MLF)

Malolactic bacteria have similar nutritional requirements as yeast, though in minimal concentrations. In addition to nitrogen and sugar, MLB requires malic acid to be present in the solution. A concentration of malic acid of 0.8 g/L or less will inhibit the start of MLF. Malolactic fermentation is also inhibited at lower pH (<3.2), high alcohol (>14%), and high free sulfur (>10ppm).

V. Off Odors (MLF)

As with alcoholic fermentation, it is important to monitor wine for off odors during MLF. During this stage, the wine is more susceptible to microbial instability. This instability can be caused by other bacterial strains, yeasts, and molds. Any odd smells or biofilms on the wine should be noted.

VI. Sluggish and Stuck Fermentations (MLF)

Since a variety of factors can inhibit MLB, MLF is subject to changes in kinetics. Most commonly, cellar temperature is the culprit, and keeping the fermentation temperature >16°C will ensure completion. Occasionally stirring the lees to reduce compaction and increase the concentration of bacteria (cells/mL) is also a common strategy. However, it is important to note that lees stirring is not always in the best interest of the wine, depending on the quality of the lees and the desired wine style.

VII. Timeline (MLF)

The time required to complete MLF will vary from wine to wine and facility to facility. Regardless of how long it takes to complete, it is important to keep in mind that the wine faces an increased risk of microbial instability during this time. To combat this potential instability, vessels can be topped with wine containing little or no free sulfur, layered with inert gas, and placed in a temperature-controlled environment.

VIII. End of Fermentation (MLF)

The end of MLF occurs when all of the malic acid has been converted to lactic, and it is said to be “malo dry.” Dryness, in this case, is typically defined as a concentration of malic acid <0.3g/L, though <0.1g/L is also a widely used benchmark. It is common to confirm the completion of MLF by testing the concentration of malic acid in the wine. This assay may need to be performed several times before a wine has completed MLF. Because of the required testing frequency, paper chromatography (Figure 9.8) is often the go-to assay, given its ease of use and affordability. This test will provide a semi-quantitative estimate of the malic acid remaining in the wine. For quantitative results or to confirm dryness indicated by chromatography, an enzymatic assay can be performed. To stop MLF, or after it has been completed, SO_2 can be added and the vessel reduced to the appropriate storage temperature for the wine.

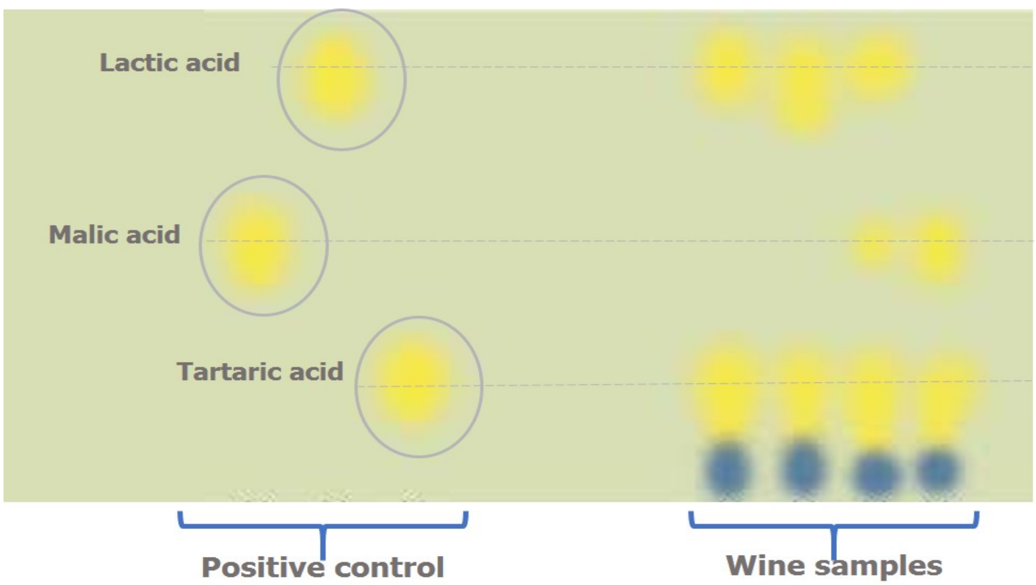


Figure 9.8 - Paper chromatography results from the testing of wine. In this case, the samples on the right with malic acid remaining would be considered unfinished. The two samples on the left-hand side have lactic acid, but no malic indicating that it has all been converted[7].

Key Points

- Fermentation is a method for cellular organisms to create energy in the absence of oxygen.
- Alcoholic fermentation of grape must is carried out by yeast, commonly *Saccharomyces*.
- Yeast requires sugar and nutrients (primarily nitrogen).
- Temperature will have a large impact on the speed of fermentation.

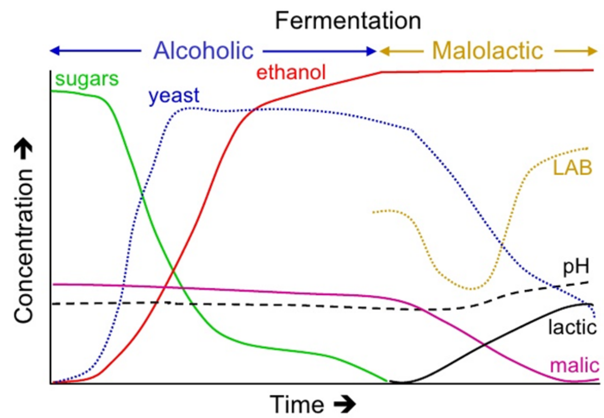


Figure 9.9 - Trends in Fermentation[9]

- Ferments should be monitored for off odors and visual defects (no CO_2, biofilms, mold, dragons, etc.).
- Alcoholic fermentation is considered dry at the depletion of glucose and fructose in solution.
- Malolactic fermentation is considered dry at the depletion of malic acid in solution.

Conclusion

Fermentation is by far the cornerstone of winemaking. A solid understanding is essential for making dynamic decisions during harvest and throughout the winemaking process. Healthy fermentations are key to creating the desired style, complexity, and flavor of a wine. Conversely, unhealthy fermentations can present unnecessary challenges at a time [harvest] where additional obstacles can quickly lead to chaos.

Chapter 10: Barrel Prep

Introduction

It makes sense that this is the last chapter because “barreling down” is one of the final tasks to close out the harvest season. After red wines have fermented in a tank or bin, they are typically settled off gross lees following pressing then transferred to barrels. The winemaker will choose barrels that they feel lend the best character to the wine and allow it to develop as they see fit. These barrels are currently empty and need to be prepared before filling. While overall a reasonably straightforward process, it is worth discussing separately.

I. Sizes

As with everything discussed thus far, there is no set “standard” when it comes to barrels. They come in almost as many sizes and configurations as tanks (Figure 10.1). The most common, however, are wooden Bordeaux barrels and Burgundy barrels in the 225L and 228L size, respectively, and stainless-steel drums of various sizes.

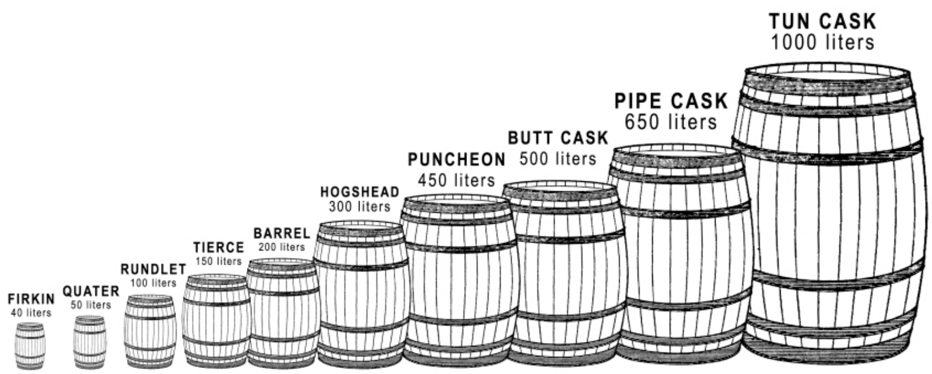


Figure 10.1 – Common barrel sizes

II. Cleaning & Storage

The first step to preparing a barrel is cleaning. Empty barrels are typically stored in one of two ways: “wet” or “dry.” This nomenclature refers to the method used for ensuring microbial stability when empty. The term “wet” indicates that a solution of acid, water, and sulfur was placed in the barrel. The term “dry” indicates that barrels are filled with sulfur dioxide gas that is periodically renewed. In either case, stored barrels often have a significant amount of sulfur that needs to be cleaned out before filling with wine.

Ozone

A common exception to this paradigm is the use of ozone to treat empty barrels. Ozone gas is generated and sprayed into the barrels every few weeks while empty. Ozone is toxic to bacteria and helps to maintain a sanitary environment inside the barrels. It can also be used with tanks and other equipment. *Note: Ozone is extremely toxic to humans as well. Please wear PPE and follow all safety precautions when operating an ozone generator (Chapter 1).*

Steaming

Empty wood barrels can be steamed, an effective method for deep cleaning. A steam wand is placed in a barrel for 5-12 minutes, and then the barrel is stoppered with a bung for several minutes. As the barrel cools and the air inside contracts, it pulls a vacuum against the bung's seal. This vacuum helps to remove compounds and microbes embedded deeply in the pores of the wood. However, steaming units are expensive and require a significant amount of electricity to operate.

Power Washing

A common alternative to steaming for wood, and standard cleaning for stainless steel, is hot pressure washing with a barrel sprayer device (Figure 10.2). Power washing will physically agitate physical debris inside of the barrel. Additionally, if high-temperature water is used, a vacuum effect similar to but less effective than steam can be produced.

It is common practice to follow steaming or hot power washing with a cold-water rinse, with some producers choosing to use an ozonated cold water rinse at this stage. The rinse removes any debris in the barrel, lowers the temperature, and expedites the closing of the pores in the wood. These actions, in concert, significantly reduce the barrel's potential for microbial infection while waiting to be filled. An exception to this may be when barrels are being prepared for soon-to-be fermenting juice rather than still wine. If the barrel is filled immediately after a hot water cleaning and rinse, this can work to the advantage of the fermentation by using the barrel's heat to help increase the temperature of the wine after cold settling in anticipation of being inoculated.

Figure 10.2 – Sideview – High-pressure barrel cleaning wand inside a barrel.

Regardless of the method used, the barrel must be placed upside down on the rack, prior to filling, to remove any remaining water. Once the water is drained, the barrel can be turned right side up and centered on the rack. It should be centered on the rack with the bunghole facing straight up. This orientation will make stacking the barrels later much easier and safer.

Barrels are typically filled with a device known as a barrel wand (Chapter 4). This is simply a stainless-steel tube with a curve at the top so one end can be connected to the hose, and the other end sits on the bottom of the barrel. Many are equipped with a threaded hole on the barrel end, allowing a stainless-steel screw to be attached. The screw elevates the wand off the barrel's bottom to avoid pulling up lees when racking. The screw is not necessary when barreling down unless the wine was fermented in a barrel and is being transferred to a different container. In this case, the screw would be helpful in the source barrel to avoid transferring gross lees. Additionally, a pressurized racking wand or bulldog (Chapter 4) could be used in this same scenario to rack the wine off gross lees into a different barrel or tank using inert gas to move the liquid rather than a mechanical pump.

III. Filling

When filling barrels, it is important to differentiate between grape juice and fermented wine. We fill barrels with grape juice with the expectation of going through fermentation. As yeast produces CO_2 (Chapter 9), the volume of liquid expands. A few inches of space should be left at the top to allow for this expansion and increased foaming capacity. Finished wines should be filled to the top of the barrel and sealed with a bung. Wines still needing to complete malolactic fermentation should have minimal headspace but cannot be sealed until the completion of MLF due to the creation of CO_2. Any juice or wine spilled on the barrel or barrel rack while filling should be cleaned off immediately after filling.

IV. Speed

Filling speed will vary depending on the pump and where you are in the filling process. Initially, the pump should be at a low speed but with enough flow to completely fill the hose and without creating air bubbles. The low initial speed avoids aeration of the wine as it leaves the barrel wand. Once the barrel wand outlet is covered, the speed can be increased. As the wine nears the top of the barrel, it is good practice to slow the speed gradually. Given the shape of a barrel, the ratio of height to volume decreases after passing the midline; therefore, the wine level will rise faster after it passes the midline. Accordingly, it is better to slow the pump down as you near the top of the barrel. A few extra seconds is a much lower cost than overflowing the barrel and losing wine to the floor drain.

V. Labeling

Much like in a chemistry lab or even a pantry, labeling is important. Before a barrel is filled, it should be labeled with the expected contents. Each winery will have its own labeling method (tape, chalk, paper, etc.) and paradigm (wine name, volume, date, etc.). Regardless of the system used, labeling is a critical step in barreling down or blending wine from barrels to a tank. In fact, labeling barrels that will not be filled or emptied is often just as crucial as labeling ones that will.

Standard industry racks hold two barrels side by side, but this does not mean they have the same wine. When moving the wine hose from barrel to barrel, it is easy to become focused on the process and mistakenly fill or empty the wrong barrel simply because it was next in line. Sometimes, this will result in a blending error that cannot be undone. Make sure to label any barrels that are not to be filled or emptied. Placing a piece of masking tape over the bung is a good practice to help with this.

VI. Additions

Barreling down can be an ideal time to make additions to your wine, for example, adding malolactic bacteria to kick off malolactic fermentation. The process of filling the barrel provides an opportunity to make additions more efficiently and effectively. Adding during filling will help to mix the addition thoroughly, ensuring proper integration. However, it is important to keep in mind with bacteria or yeast that once the addition is made during filling, the barrel wand should be considered “contaminated” with bacteria and not touch other wine until it has been adequately cleaned.

VII. Finished

Once a barrel is filled, it is important to add a bung as quickly as possible to avoid atmospheric exposure (Chapter 7). The type of bung used will vary depending on when in the winemaking process you have barreled down. For a wine that is to be fermented (alcoholic or malolactic), some type of fermentation bung is best. For wines that are entering the aging process, a solid bung is preferred. Once this is complete, ensure that any wine or juice spilled on the barrel is cleaned immediately. Red wine spilled on a barrel will stain if not immediately cleaned with a brush and chemicals. Full barrels at the end of harvest, are often accompanied by a sigh of relief and a good night of sleep. However, it is important to remember that the work is far from over.

Conclusion

Barrels are unique in that they often are used to visually represent wines and wineries, and with good reason. They are more integral to the wine world than any other single piece of equipment. Beyond a simple visual representation, full wine barrels represent a milestone in the winemaking process. New wine is being put away, and harvest season is coming to a close. However, it is essential to remember that the work is far from over. Likely some wines are still completing malolactic fermentation, and of course, somewhere, something always needs cleaning.

Appendix I: Glossary

Acetic acid - One of the primary volatile acids in wine.

Acidity - The quality of wine that gives it its crispiness and vitality. The three main acids found in wine are tartaric acid, malic acid, and lactic acid. The first two come from the grapes and the third from malolactic fermentation which often occurs in the winemaking process.

Aerobic - Conditions that promote exposure to oxygen, such as wine barrels kept partially full to age the wine oxidatively.

Alcohol - Generally refers to ethanol, a chemical compound found in alcoholic beverages. It is also commonly used to refer to alcoholic beverages in general.

Alcoholic Fermentation - Conversion by yeast of sugar into alcohol compounds.

Aldehyde - A component of wine that is formed during the oxidation of alcohol. It is midway between an acid and an alcohol.

Amino Acids - Building blocks of proteins, found in grapes, and consumed/utilized by yeast during the fermentation process.

Anaerobic - The opposite of aerobic, referring to a chemical process that takes place in the absence of oxygen. As a wine ages in a sealed wine bottle, it is going through anaerobic changes.

Anthocyanins - Phenolic pigments that give red wine its color.

Antioxidant - Chemicals, such as sulfur dioxide, that are used to prevent the grape must from oxidizing.

Aroma - Refers to the primary smell characteristics of the wine and/or faults in the wine.

Aromatized Wine - Wine that has been flavored with herbs, fruit, flowers, and spices. Examples: Vermouth, Retsina, or mulled wine.

Ascorbic Acid - Antioxidant used to prevent grape must from oxidizing (Vitamin C).

Aseptic - The characteristic of a chemical or technique designed to kill/avoid bacteria.

Assemblage - The blending of base wines to create a final blend or cuvée.

Barrel Fermented - Wine fermented in oak barrels as opposed to stainless steel or concrete tanks.

Barrique - French term for a 225 liter barrel that is traditional to Bordeaux and now adopted worldwide.

Baumé- French measurement of the sugar concentration in the juice or wine.

Bentonite - A type of clay of volcanic origins used in wine as a fining agent to remove unstable proteins.

Blending - The mixing of two or more different parcels of wine together by winemakers to produce a consistent finished wine ready for bottling. Laws generally dictate what wines can be blended and what is subsequently printed on the wine label.

Blue Fining - Use of potassium ferrocyanide to remove iron or copper casse from a wine.

Blush Wine - A pale, pinkish color wine. It may refer to a sweet rosé such as White Zinfandel.

Body - Refers to the sense of alcohol in the wine and its feeling in the mouth.

Botrytized Grapes - Grapes infected by *Botrytis cinerea*, a common fungus.

Bouquet - Refers to the smell of the wine's secondary characteristics arising from techniques used during the winemaking process, aging of the wine, or faults in the wine.

Brettanomyces - A wine spoilage yeast that produces taints in wine commonly described as barnyard or band-aids.

Brix - A measurement of the dissolved solids in grape juice (g/100mL).

Cap - The layer of grapes and grape skins forced by carbon dioxide gas to the top of the fermentation vessel.

Carbon Dioxide Gas (CO_2) - An inert gas created as a metabolic by-product of fermentation. A small amount will dissolve into the wine, but most of the gas will rise to the fermentation vessel's surface and escape into the atmosphere. Also used to protect still wines from oxidation (Chapter 7).

Carbonic Maceration - Winemaking practice of fermenting whole grapes that have not been crushed. This intracellular fermentation (as opposed to the traditional extracellular fermentation of wine yeast) tends to produce fruity, deeply colored red wines with low tannins.

Casein - A fining agent derived from a milk protein.

Casse - An unwanted haze in wine caused by various unstable compounds (such as proteins or excess copper from previous finings) can develop into a wine fault if not corrected before bottling.

Cellaring - To age wine for the purpose of improvement or storage.

Centrifugal Filtration - Process of separating unwanted particles (such as dead yeast cells or fining agents) from the wine using centrifugal force.

Chaptalization - A winemaking process where sugar is added to the must to increase the alcohol content in the fermented wine. This is often done when grapes have not ripened adequately.

Clarification - A winemaking process involving the fining and filtration of wine to remove suspended solids and reduce turbidity.

Cold Stabilization - A winemaking process where wine is chilled to near freezing temperatures for several weeks to encourage the precipitation of tartrate crystals.

Color - One of the most easily recognizable characteristics of wines. An element in the tasting, analysis, and classification of wines and grape products.

Crossflow Filtration - High-speed form of microfiltration utilizing tangential flow across a membrane.

Crush - During processing, grapes can be "crushed" or broken up so that the juice is released and allowed to macerate with the skins before and during fermentation. Also used as a synonym for harvest time.

Cryoextraction - A mechanical means of concentrating the grape must (and such increasing sugar concentration) by chilling the must until its water content freezes into ice crystals that are then removed. This production method is used to make so-called "icebox wines" in a style similar to ice wines which are produced by the grapes naturally freezing on the vine before harvest

Cuvée - A wine blended from several lots or batches or a selected lot, also used in Champagne to denote the juice from the first pressing.

Debourbage - Refers to a process in which the must of a white wine is allowed to settle before racking; this process reduces the need for filtration or fining.

Délestage - French term for racking to remove harsh tannins from the wine in the form of grape seeds. In this process, the wine is drained into a secondary vessel, allowing the cap to settle to a bottom and loosen the seeds that are trapped in the pulps. As the wine drains, a filter captures the seeds and removes them from the wine. The wine is then returned to the first vessel.

Depth filtration - Means of filtering a wine that takes place solely inside filtration media, such as a DE filter, rotary drum vacuum, or a plate and frame filter.

Diatomaceous Earth (DE) - Very fine particles of sedimentary rock used for filtering wine. Known carcinogen.

Dry - Wines with zero or very low levels of residual sugar. The opposite of sweet, except in sparkling wines, where dry means sweet.

Egg White Fining - Technique of fining that uses the whites of eggs to attract negatively charged matter.

Enology - American English spelling of oenology, the study of wine.

Enzyme - A protein that acts as a biochemical catalyst, speeding up reaction rates. Example: The enzyme invertase aids the storage of sugars within individual grape berries.

Esters - Compounds formed in wine either during fermentation or the wine's aging development that contribute to aroma.

Ethanoic Acid - Another name for acetic acid.

Ethanol - Also known as "ethyl alcohol." The primary alcohol in wine and most other alcoholic beverages.

Ethyl Acetate – Metabolic by-product of yeast that smells of paint thinner and nail polish remover.

Extraction – The removal of gape components into solution (juice or wine). High levels of extraction often result in more color and body, which may be increased by prolonging the wine's contact with the skins.

Fault - An unpleasant characteristic of wine resulting from a flaw with the winemaking process or storage conditions.

Fermentation - A metabolic process used to create energy. In the alcoholic fermentation of wine, sugars are converted to alcohol and carbon dioxide by yeast. In malolactic fermentation conversion, malic acid is converted to lactic acid by bacteria.

Fermentation Curve - When the temperature and must density/sugar levels of an individual vat or tank of fermenting must are plotted on a graph to track progress from the initiation of fermentation to dryness.

Filtration - The removal of unwanted particles suspended in wine or grape juice.

Fining - A clarification process where flocculants, such as bentonite or egg white, are added to the wine to remove suspended solids. Fining is considered a more gentle method of clarifying a wine than filtering.

Finish - Refers to the sense and perception of the wine after swallowing it.

Flash Pasteurization - A procedure different from full pasteurization where the wine is subjected to high temperatures around 176°F (80°C) for intervals of 30-60 seconds.

Flor - The yeast responsible for the character of dry Sherries.

Fortification - The process of adding pure alcohol or very strong (77 to 98 proof) grape spirit to a wine. Depending on when the alcohol is added, either before, during, or after fermentation, this can result in a wine with high alcohol content and noticeable sweetness.

Foudre - A generic French term for a large wooden vat between 20 and 120 hectoliters.

Free Run - Juice obtained from grapes that have not been pressed.

Free Sulfur - Active element of sulfur dioxide that is unbound and remains available for reaction with other molecules.

Fusel Alcohol - Also commonly called "higher alcohols," they are alcoholic by-products of fermentation that contain three or more carbons. In small quantities, they can contribute to a wine's complexity.

Gelatin - A fining agent derived from animal tissues used to remove excessive amounts of tannins and other negatively charged phenolic compounds from the wine.

Geosmin - A chemical compound found in wine grapes that is responsible for some earthy aromas and flavors. Geosmin is also found in beets and potatoes.

Governo - Winemaking technique historically associated with Chianti where a small amount of partially dried grapes are added to a lot of wine that completed or stopped fermentation to restart fermentation, potentially adding more alcohol and glycerin to the wine.

Grape Juice - Free-run or pressed juice from grapes. Unfermented grape juice is known as "must."

Gyropalette - A mechanized riddling palate that can complete the remuage process that would manually take several weeks over the course of a few days.

Hydrogen sulfide (H_2S) - A combination of hydrogen and sulfur that can produce a fault in the wine reminiscent of the smell of rotting eggs.

Isinglass - A clarifying agent, derived from the bladder of sturgeon.

Lactic acid - Acid in wine formed during the process of malolactic fermentation.

Lactic acid bacteria - A class of bacteria capable of converting malic acid to lactic acid to produce energy

Lees - Wine sediment that occurs during and after fermentation, and consists of dead yeast, grape proteins, and other solids. Wine is separated from the lees by racking.

Lees Stirring - Also known as bâttonage, a process associated with sur lie aging where the lees are stirred up to extract flavor and other sensory components into the wine and to avoid reductive conditions that may contribute to various wine faults

Maceration - The contact of grape skins with the must during fermentation, extracting phenolic compounds including tannins, anthocyanins, and aroma.

Madeirized - A wine showing Madeira-like flavor, generally evidence of oxidation. Sometimes used to describe white wine that has been kept long past its prime.

Maillard Reaction - Chemical reaction between amino acids and sugar and different temperatures. Responsible for the various flavors produced by toasting an oak barrel

Malic Acid - A strong tasting acid in wine similar to green apples. The amount of malic acid in grapes is gradually reduced during the ripening process while the grapes are on the vine and can be further reduced during winemaking by fermentation and malolactic fermentation.

Malolactic Fermentation - Also known as malo or MLF, a secondary fermentation in wines by lactic acid bacteria during which malic acid is converted to lactic acid, producing carbon dioxide.

Mannoprotein - A protein attached to a mannose sugar that is commonly integrated into the cell walls of yeast. During the autolysis process (death of yeast cells) that occurs while the wine ages on its lees, these proteins are released into the wine.

Membrane Filtration - Process of filtration that uses a thin screen of biologically inert material, perforated with microsize pores that capture matter larger than the holes' size.

Mercaptans - Chemical compounds formed by the reaction of ethyl and methyl alcohol with hydrogen sulfide to produce a wine fault that creates typically undesirable odors.

Microoxygenation - Controlled exposure of wine to small amounts of oxygen to encourage polymerization of phenols

Microvinification - A winemaking technique often used for experimental batches of wine where the wine is fermented in small, specialized vats.

MOG - A winemaking abbreviation for "Material Other than Grapes." Usually refers to debris like leaves, dirt, and stems that can be unintentionally harvested with the grapes.

Must - Unfermented grape juice

Mutage - French term for fortifying a wine by adding alcohol to the must either before fermentation.

Oak - The most commonly used wood source for fermentation vessel and barrel aging. Oak influence can also be imparted to a wine by the use of oak chips or staves.

Oenology - The science of wine and winemaking.

Off-Dry - A wine that has the barest hint of sweetness; a slightly sweet wine in which the residual sugar is barely perceptible, typically less than 1 but greater than 0.5g/L

Orange Wine - White wine with extending skin contact, similar to red wine production.

Organic Winemaking - Style of winemaking using organically grown grapes and a minimum amount of chemical additives.

Osmotic Pressure - The tendency of water within two solutions separated by a semipermeable membrane to travel from a weaker solution to the more concentrated one to achieve equilibrium. In winemaking, osmotic pressure is observed in yeast cells added to grape must with high sugar content. The water in the yeast cell escapes through the cell membrane into the solution causing the cell to experience plasmolysis, caving in on itself and dying.

Oxidation - Technically: The loss of an electron. Commonly: The degradation of wine through exposure to oxygen. In some aspects, oxygen plays a vital role in fermentation and through the aging process of wine. But excessive amounts of oxygen can produce wine faults.

Pad Filtration - Technique of filtering wine that involves running the wine through a series of pads made of asbestos, cellulose, or thin paper sheet. A form of depth filtration.

Palate - The sensory taste of a wine, it's flavors, textures, and overall structure.

Pectic Enzyme - An enzyme added to fruit to increase juice yield by breaking down pectin. It is also used as a clarifying agent in fruit wines when added to wine or must eliminate pectin hazes.

Perlite - A fine, powder-like substance of volcanic origins that is sometimes used for ceramic filtration. It has many of the same filtering properties as diatomaceous earth.

Phenolic Compounds - A class of compounds that contribute vital characteristics to the color, texture, and flavor of a wine. Two of the most notable phenols in wine include anthocyanins which impart color, and tannins, which add texture.

Polyvinylpolypyrrolidone/PVPP - A fining agent, more commonly called PVPP, is used in white wine production to remove compounds that can contribute to premature browning of the wine.

Pomace - The skins, stalks, and pips (seeds) that remain after making wine.

Potable Alcohol - Another term for ethanol or ethyl alcohol. Accounts for the majority of alcohol compounds found in wine. Non-potable alcohols include methanol and higher alcohols.

Potential Alcohol - The calculation, based on the concentration of sugar in must, of the potential finished alcohol levels if that must is fermented to dryness.

PPM - Parts per Million. 1ppm = 1mg/L

Pre-fermentation Maceration - The time before fermentation that the grape must spends in contact with its skins. This technique may enhance some of the varietal characteristics of the wine and leech important phenolic compounds out from the skin. This process can be done either cold (also known as a "cold soak") or at warmer temperatures.

Protein Haze - Condition in wine where heat denatures unstable proteins and produces a haze in the wine. Commonly avoided with the use of a fining agent, such as bentonite, to remove the proteins.

Puncheon - An oak wine barrel with the capacity of 450 liters

Pyrazines - A group of aromatic compounds in grapes that contribute to green and herbaceous notes in wine, including the green bell pepper notes typical of Cab Franc.

Racking - The process of drawing wine off the sediment, such as lees, after fermentation and moving it into another vessel.

Remontage - French term for the process of pulling out wine from underneath the cap of grape skins and then pumping it back over the cap to stimulate maceration.

Residual Sugar - Unfermented sugar leftover in the wine after fermentation. All wines contain some residual sugars due to unfermentable sugars in the grape must such as pentoses.

Reverse Osmosis (RO) - Form of filtration that uses osmotic pressure to remove excess water or alcohol from wine.

Rosé - Pink wines, typically produced by shortening the contact period of red wine juice with its skins, resulting in a light red color.

Saignée - Pronounced "Sahn yay" is the removal of grape juice from the "must" before primary fermentation to increase a wine’s skin/juice ratio, typically done after 24 hrs of cold soak and before inoculation. The wine removed is commonly used to make Rosé.

Skin Contact - Another term to describe maceration.

Solera System - Process used to blend various vintages of Sherry systematically.

Sparging - A process of bubbling gas to a wine. This technique can be used to remove dissolved oxygen or increase dissolved CO_2.

Spinning Cone Column - Technique used to reduce the concentration of alcohol in wine.

Stabilization - The process of decreasing the volatility of wine by removing particles that may cause unwanted chemical changes after the wine has been bottled. In winemaking, wines are stabilized by fining, filtration, adding sulfur dioxide, or techniques such as cold stabilization where tartrate chemicals are precipitated out.

Still Wine - Wine that is not sparkling wine.

Stoving Wine - Production method of artificially mellowing wine by exposing it to heat.

Stuck fermentation - Fermentation that has been halted due to yeast prematurely becoming dormant or dying. There are various causes for stuck fermentation, including high/low fermentation temperatures, yeast nutrient deficiency, or excessively high sugar content.

Sulfites - Class of compounds that are both produced by yeast and added to wine to prevent oxidation, microbial spoilage, and further fermentation by the yeast. Ionic form is pH-dependent.

Sulfur Dioxide - A substance used in winemaking to prevent microbial spoilage.

Sur lie - A winemaking practice that involves prolonged aging on the dead yeast cells (the lees).

Süssreserve - A reserve of unfermented grape juice that is added to wines as a sweetening device.

Tannin - A set of phenolic compounds that generally give the wine a bitter/dry feeling in the mouth while also acting as a preservative/anti-oxidant and giving the wine its structure.

Tartaric Acid - Primary acid found in grapes and wine. Prior to veraison, the ratio of tartaric and malic acid in grapes is equal, but as malic acid is metabolized and used up by the grapevine, the proportion of tartaric sharply increases.

Tartrates - Crystalline deposits of the tartaric acids that precipitate out of the wine as increasing alcohol and lower temperatures decrease their solubility.

Terpene - A class of unsaturated hydrocarbons responsible for certain aromas that are characteristic of a grape variety such as the petrol notes of mature Riesling or the floral aroma of Muscats.

Titratable Acidity (TA) - The amount of acid in must or wine that can be estimated through standard lab techniques (titration). It is commonly used interchangeably with “total acidity” but instead actually serves as an adjunct since measuring total acidity takes advanced lab techniques and equipment not available to most wine producers.

Toast - The charring of the wine staves during cask manufacture or rejuvenation.

Topping - The process of filling the headspace created inside a barrel from wine evaporation.

Total Acidity - Total amount of acidity (tartaric, lactic, malic, etc.) in wine as measured in grams per liter.

Total Sulfur - The concentration of sulfites in wine, including those that are both free and bound. Typically reported in ppm.

Ullage - Also known as headspace, the unfilled space in a wine bottle, barrel, or tank. Derived from the French ouillage, the terms "ullage space" and "on ullage" are sometimes used, and a bottle or barrel not entirely full may be described as "ullaged." It also refers to the practice of topping off a barrel with extra wine to prevent oxidation.

Vanillin - An aldehyde found naturally in oak that imparts a vanilla aroma in wine.

Varietal - A wine made from a single grape variety.

Véraison - French term (now English also) for the onset of ripening of the grape cluster.

Vinification - The process of making grape juice into wine.

Vinous - A wine that tastes like grapes, displaying no varietal fruit or winemaking characteristics.

Volatile Acidity - A classification of acids that are detectable on both the nose and the palate. Acetic acid is the most common, and often they are used interchangeably. However, this classification includes several others such as ethyl acetate, butyric, formic, and propionic acids. Excessive amounts of VA are considered a wine fault.

Volatile Phenols - Phenolic compounds found in wine that may contribute to odors. Example: ethyl-4-guaiacol, a metabolic by-product of *Brettanomyces*.

Wine -An alcoholic beverage made from the fermentation of unmodified grape juice.

Wine Fault - Undesirable characteristics in wine caused by poor winemaking techniques or storage conditions.

Wood Lactones - The various esters that a wine extracts from oak or other woods.

YAN - Yeast Assimilable Nitrogen, a measurement of amino acids and ammonia compounds used by wine yeast during fermentation.

Yeast - A microscopic unicellular fungi that commonly uses fermentation to create energy

Yeast Enzymes - Enzymes within yeast cells that act as a catalyst for a specific activity during the fermentation process.

Appendix II: Safety Orientation

Please read the following outline and initial on the line indicating you understand the risks and procedures associated with each section. If you have any questions, please review Chapter 1 and follow up with your winery's staff.

1. Inert Gas Initials: ______
   a. Source: fermentation or bottled gas
   b. Types: CO_2, Nitrogen, Argon – Heavier than air
   c. Danger: Not toxic but causes rapid suffocation
   d. Hazards of enclosed spaces
      i. Tank entry procedures, during harvest and otherwise
      ii. Other enclosed spaces: i.e., presses and barrel rooms
      iii. O_2/CO_2 monitoring

2. Chemical Handling Initials: ______
   a. SDS Sheets: Location in the winery or available online
   b. Location of gloves and goggles
      i. I understand that it is my responsibility to wear gloves and goggles while working with chemicals and that this responsibility exists regardless of whether I am directed to do so for a specific task. Initials: ______

   c. Location of eyewash station, emergency showers, and first-aid kit
   d. Sulfur Dioxide: Solid, liquid, and gas
      i. Half-mask respirator
      ii. Increased fume hazard when combined with acids
   e. Caustic chemicals and acids
   f. Ozone machine
      i. Exposure limits .3 ppm for 15 minutes or .1 ppm for an 8-hour workday
   g. Do not mix chemicals and be precise with concentrations

3. Heights Initials: ______
   a. Barrel Climbing
      i. Full vs. empty barrels
      ii. Signs of a dangerous stack
   b. Ladders
      i. A-frame and extension ladders
      Don't use A-frames as straight ladders
      ii. Rolling ladders
      iii. Punchdowns

4. Machinery hazards Initials: ______
   a. General machine safety
      i. Disconnect power before dismantling
      ii. Location of emergency stops

iii. Safety guards
iv. Check instructions

b. Press
c. Crusher de-stemmer
d. Pumps

5. Electricity — Initials: ______
    a. Types of power in wineries
    b. Caution around water
    c. Extension cords and non-commercial electronics

6. Safety around forklifts — Initials: ______
    a. Never stand beneath a load
    b. Giving the driver space
    c. Doorways and "courtesy honks," door positions
    d. Correct barrel positioning on racks

7. Hot Water — Initials: ______
    a. Residential hot water: 135-150 ºF
    b. Process water: 170-180 ºF.

8. Pressure — Initials: ______
    a. Sources – Bottled gasses, air pump, fermentation
    b. Signs of pressure – Jumping hoses, stiff clamps, bulging

9. Lifting — Initials: ______
    a. Proper lifting technique – know your limits
    b. Making use of labor-saving devices and machines

10. Alcohol Consumption — Initials: ______
    a. Taste wines only under the direction of the winemaker
    b. Wines should be sampled and spit

11. Self-Care — Initials: ______
    a. Proper clothing
    b. Sleep
    c. Manage stress and mental health

12. Miscellaneous — Initials: ______
    a. Cryogenics
        i. Dry Ice (Also inert gas hazard)
        ii. Escaping gas
    b. Fire – Location of fire extinguishers
    c. Noise
    d. Bee Stings
    e. Safe area
    f. Location of First Aid Kit

Appendix III: Forklift Training

Introduction

Operating a forklift requires skill, training, and experience. Although it may seem as easy as driving a car, many factors make driving a forklift more difficult. Learning how to operate a forklift safely can help prevent accidental injuries and possible death. Forklift training aims to help you achieve a work environment that is accident free and meets OSHA regulations.

IMPORTANT NOTE: This training is **NOT** a substitute for a formal forklift operations class or license. This training aims to familiarize you with the steps of how forklifts are operated and how to function in a work environment that uses forklifts. Specific topics you will learn about include:

1) How forklifts can be operated safely.
2) Pre- and post-operation procedures.
3) Inspection and maintenance of the forklift.

A properly operated forklift, along with carefully followed safety procedures, will go a long way towards reaching the goal of a safe working environment at all times.

I. What is a Forklift?

A forklift is one type of powered industrial truck that comes in different shapes, sizes, and forms. A forklift can be called a pallet truck, rider truck, fork truck, or lift truck. Yet, the ultimate purpose of a forklift is the same: to safely allow one person to lift and move large, heavy loads with little effort. For the purposes of this training, a forklift is a large industrial truck with a power-operated pronged platform.

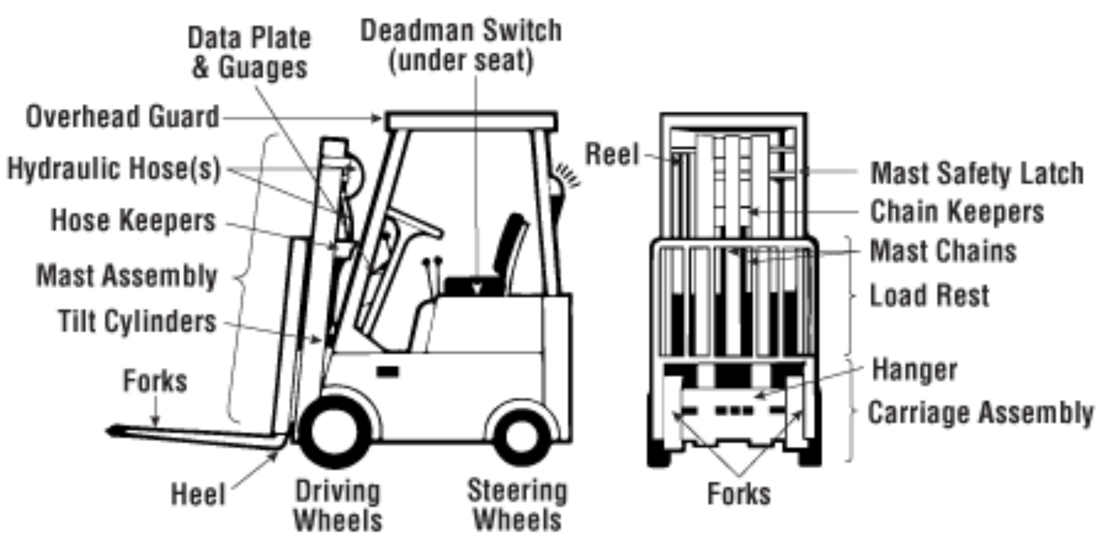


Figure A3.1 – Parts of a Forklift[3]

A forklift operator should be aware of the multiple parts on a forklift (Figure A3.1) to safely operate the forklift and detect when an unsafe vehicle needs to be removed from service. Be sure to familiarize yourself with the parts on the forklift used in your winery.

Safety

The Bureau of Labor Statistics estimates that approximately 90,000 forklift accidents occur annually, resulting in employee injuries, lost time, or death. The four most common forklift-related deaths are overturns, workers on foot being struck, crushing, and driver falling from the forklift. It is estimated that inadequate training, at least in part, causes many of these accidents. So, during your forklift safety training, always keep in mind that you are being trained for the safety of yourself and others around you.

II. Authorized Operators

Receiving your certification for a forklift is very similar to gaining a driver's license for an automobile. To qualify, training must occur under the supervision of an experienced forklift operator and must consist of the following three parts:

- Formal instructions such as lecture, discussion, interactive computer learning, videotape, or written material.
- Practical training, including hands-on demonstrations by the trainer and exercises by the trainee (on the type of forklift you will use for your work).
- An evaluation of the training's effectiveness by observing your performance while doing actual work using the forklift.

Once you have been trained, recertification is required every three years or sooner if you are involved in an accident or near-miss.

III. Differences Between Forklifts and Autos

Steering

Operating a forklift is different than driving an automobile in many ways. For example, in most autos, the front wheels steer the vehicle in the direction you want to turn or travel. On a forklift, the rear wheels control the steering. The back end of the forklift swings in a circle around the front wheels that support most of the load you are carrying. Because of this large turning circle, always check to make sure there is room for the rear end to swing because it can swing out further than you expect and possibly cause an accident.

Braking

There is also a difference between a forklift's and a car's capability to stop. In an auto, the steering system works together with the brakes to guide you to a smooth stop. But, the rear steering on a forklift can make it challenging to swerve and react quickly. Therefore, remember to drive at a safe speed and be aware of your surroundings.

Weight

Although smaller than a car, a forklift is two to three times heavier. The average forklift can weigh from 3,000 to 4,500 pounds. A large counterweight is mounted on the rear to balance heavy loads and prevent the forklift from tipping over. This counterweight is a part of the forklift's structure and should never have anything added to it in an attempt to balance the load out.

<u>Stability</u>

Forklift stability is an important topic because the leading cause of death and severe injury involving forklifts stems from overturns caused by forklift instability. Four elements can describe forklift stability: the fulcrum point, center of gravity, the stability triangle, and the load center.

Fulcrum Point

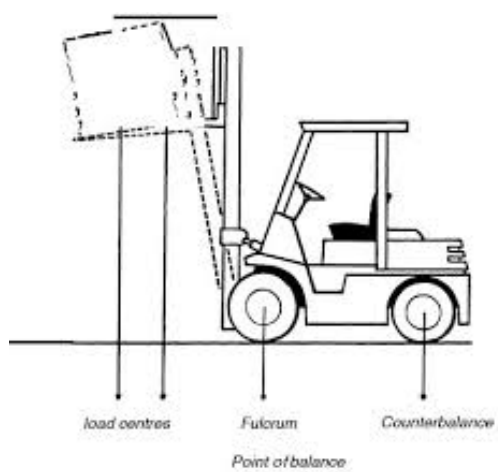


Figure A3.2 – Fulcrum Point[4]

The fulcrum point may sound complicated, but think of a seesaw: a board that is balanced in the middle by a support piece. This support piece is what is called the fulcrum point. On a forklift, the fulcrum point is the front wheels. The fulcrum point serves as a support piece to balance the load and counterweight.

Center of Gravity

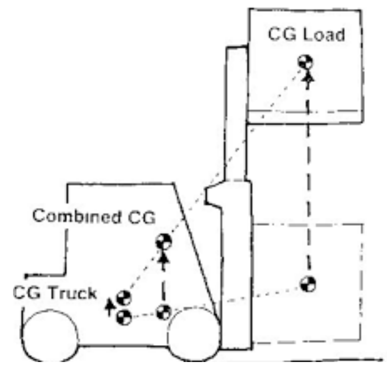


Figure A3.3 – Center of Gravity[4]

In addition to balancing both ends of the forklift, we must also balance in all directions. The point where all parts of a load and truck are balanced in all directions and remain at rest is commonly known as the "center of gravity". As a driver, it is essential to remember that a new center of gravity is created when carrying a load that combines both the load and the truck's center of gravity. Think of it like riding a tricycle. If you peddle a tricycle around a corner and shift the center of gravity over the narrowest part of the tricycle, you are likely to turn over. However, if you shift your weight to the rear and the center of gravity over the widest part of the tricycle, you are less likely to tip over.

Stability Triangle

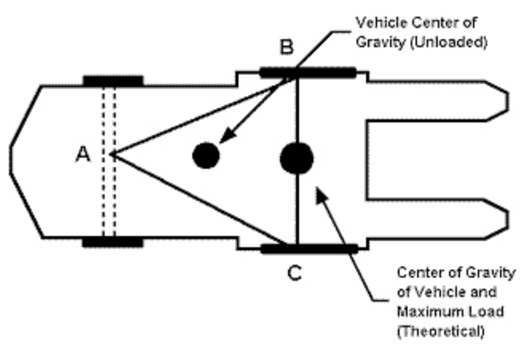


Figure A3.4 – Stability Triangle[5]

That brings us to the stability triangle, the triangle on wheels. Think of the stability triangle as three imaginary lines connected by the center axle to the forklift's front wheels. To maintain a stable forklift, you must keep the center of gravity within the stability triangle.

The most stable area while handling a load is close to the base of the forklift. If the load you are carrying moves too far forward from the forklift's base, it will more than likely tip forward. Some factors that could cause instability are:

- Carrying a load too high
- Excessively tilting the load forward
- Operating on a decline
- Heavy Braking
- Inappropriate use of forklift attachments
- Off-center loads
- Uneven terrain
- Quick turns

However, your potential to turn over can be reduced if you follow a few safety rules:

- ➢ Make sure the load is stable and safely arranged on the forklifts.
- ➢ Do not tilt the forks forward except when picking up or depositing a load.
- ➢ Keep the load low just above the pavement with the forks tilted back when traveling.
- ➢ Enter tractor-trailers or elevators squarely when picking up or depositing loads.
- ➢ Drive at a slow enough speed to allow you to stop safely.
- ➢ Drive slowly on wet or slippery surfaces.
- ➢ Avoid driving on unstable surfaces or where there are loose objects on the surface.

Load Center

Finally, keep the load center in mind when trying to remain stable or achieve stability. The load center of a forklift is simply the distance from the forks' front face to the center of the load. The most important thing to remember is that the further you move from the load center when hauling a load, the lower capacity your truck will handle. Check with your supervisor to determine the maximum capacity that your winery's forklift can handle. This information can be found on the data plate, typically located on the front of the forklift.

Pre-inspection

Your forklift should be inspected for defects every day before and after your shift. You should conduct your inspection as follows:

- Look around the forklift completely for any signs of defects.
- Inspect the general condition and cleanliness of the forklift.
- Check your oil, fuel, and radiator level. If the forklift is electric, check the electrolyte level, battery plug, and connections.
- Look for evidence of any damage (e.g., missing or loose bolts, nuts, chains, etc.).
- Observe condition of wheels and tires.
- Honk the horn to ensure it is working properly.
- Make sure the forks are in working condition.
- Determine whether the chain anchor pins are worn, loose, or bent.

- Look for fluid leaks, damp spots, or drips
- Make sure hoses are held securely in place.
- If authorized, check the battery cables and water levels.
- Look for objects on the floor or overhead that could lead to an accident.

Never use an unsafe forklift. If you discover that the forklift needs repair, do not try to fix it yourself unless authorized to do so. Immediately take the forklift out of service and report it to your supervisor. The damage it can cause if driven puts your safety and the safety of others at risk.

<u>Operation</u>

Mounting/ Dismounting

Particular precaution should be taken when mounting and dismounting the forklift so that you don't slip, trip, or fall. The correct way to mount the forklift requires you to use three contract points, which act as a support system to prevent you from falling. This means that both of your hands and one foot should be in contact with the forklift at all times. Additionally, you should always mount and dismount the forklift on the side without the gearshift. Never jump on or off of the forklift.

Safety Features

Failure to wear a seat belt can result in you being thrown outside of the forklift cage, causing severe injury, so protect yourself by buckling up.

Also, for your own safety, never start a forklift or attempt to operate it from outside the vehicle. You must always start the engine and operate the forklift from the driver's seat to ensure the forklift does not jump out of gear and cause an accident. Failure to do so could cause injury to others or yourself and damage to your surroundings.

Forks

Once the engine is started, but before you drive the forklift, make sure the forks are low to the ground. Forks should be positioned approximately 2-4 inches high while you are driving. However, you may need to adjust the forks if the planned route you are taking contains bumps, seams, or uneven terrain. Never allow anyone to walk or stand under the elevated forks (even if the forks are not loaded) because it may result in injury or accident.

"Pedestrians"

While you are driving, be sure to keep a safe distance away from others as they always have the right of way. In areas where your vision is reduced, you should slow down and sound your horn to notify potential pedestrians that you are entering the area. Like the road rules, you should also yield the right of way to approaching pedestrians. Stop and allow them to pass before driving is resumed.

Loading Docks

Take precaution to drive a safe distance from the edge of loading docks or ramps. Driving too close to the edge of a loading dock or a ramp may reduce your chance of stopping the forklift quickly due to slippery surfaces and the vehicle's weight. Also, drag racing or stunt driving should never be permitted as it could lead to a possibly fatal accident.

Loads

Forklifts are often driven onto trucks, trailers, or railroad cars over a dock board (better known as "bridge plate") at loading docks. Before driving the truck in to a truck, trailer, or railroad car, check the flooring for any breaks or weaknesses. Also, make sure the trailer, truck, or car has been appropriately secured. Truck brakes should be set and wheel chocks placed under the rear wheels to prevent the truck from rolling while the forklift driver is aboard. Never depend on anyone to make sure the vehicle is secured to the dock. Check it out for yourself to ensure your own safety.

Ensure the weight of the load does not exceed the amount that your forklift can handle. If the load is too heavy, you should break the load into smaller parts. When transporting a load up an incline, drive up the incline with the load in front of you. When exiting, drive back down with the forks still facing the incline. This will help prevent the forklift from tipping. After inspecting the load, you can safely pick up the load by doing the following:

- Move squarely into position.
- Position the forks wide apart to keep the load balanced.
- Drive the forks fully under the load.
- Tilt the mast backward slightly to stabilize the load and lift.
- If the load you are carrying obstructs your view, carefully travel in reverse, with the load trailing.

There are additional rules of thumb that will protect you and others while operating a forklift:

- Keep your feet, arms, and head inside of the forklift at all times to avoid an injury from unknown objects in the isles.
- Do not allow anyone but the operator to ride on the forklift unless designed to carry more than one person.
- Stay alert to challenging or unusual conditions so you can react to them.

Post Operation

When you are finished operating the forklift, several precautions should be followed to ensure the vehicle is securely shut down. When you are finished operating the forklift, lower the forks flush to the ground to ensure they cannot injure a co-worker. Set the gearshift to neutral, turn off the power, remove the key, and set the brakes to avoid movement. Finally, dismount by holding onto the forklift with both hands and stepping down, one foot at a time, to give yourself the support to dismount safely. Also, chock wheels if necessary.

Maintenance

In addition to the daily pre-operation inspection, check the vehicle after usage to determine if any new defects exist. A forklift in need of repair can lead to many safety issues if it is not serviced in a timely manner. If you discover that a forklift is unsafe, you should immediately remove the forklift from operation so that no one attempts to use it until it is repaired. Notify your supervisor or authorized person about the maintenance issue(s) as soon as possible.

A forklift should be kept clean, free of lint, excess oil, and grease to ensure that the controls and the vehicle operate properly. Your company may authorize an individual to make sure the forklift is clean. Check with your instructor to determine who is assigned to this task.

Fueling/Charging

Fueling or charging a forklift is an important step in the operation of a forklift. There are many hazards involved, such as exposure to chemicals and flammable materials, so you must take all of the necessary safety precautions. If you are authorized to refuel or charge a forklift, be sure to:

- Identify where your eyewash station is located in case of an emergency in case you are exposed to hazardous materials.
- DO NOT smoke or allow any open flames in the refueling/charging area.
- Make sure there is sufficient ventilation in case of fumes.
- Verify there is a fire extinguisher nearby.
- Put a barrier in place that protects the pump or charger against vehicle damage.

Charging a Battery

You should only charge or service the battery if you are authorized to do so. Review the forklift manufacturer's manual for recommendations before charging or maintaining the battery. When adding fluid to the battery:

- Wear safety glasses and a face shield for protection against electrolyte splash or spray.
- Properly position the forklift and apply the brakes before charging the battery.
- Remove any tools and other metal objects away from the top of uncovered batteries to prevent an explosion due to short-circuited terminals.
- Know where the nearest eyewash station or shower is located to flush out or neutralize spilled electrolyte.
- If acid is spilled on your clothes, wash it off immediately with water.
- Make sure the ventilation system is working in the designated changing area.
- If you are charging the battery on the forklift, be sure to uncover the battery compartment to prevent a build-up of heat and hydrogen gas.
- Make sure that battery vent caps are not plugged and the battery covers are open.
- Unplug or turn the charger off before attaching or removing the connections.
- Carefully attach the clamps to the battery in proper polarity (red to positive and black to negative).

Forklift Training Quiz

1. If you have a valid driver's license, you are qualified to operate a forklift.

    True or False?

2. Operating a forklift is different than driving a car in the following ways:

    a. A forklift has rear-wheel steering, and most cars are front-wheel steering.
    b. A forklift is much heavier than a car
    c. A forklift has a 3-point suspension, and a car has a 4-point suspension
    d. All of the above

3. The front wheels of a lift truck serve as the ___________between the weight of the truck and the weight of the load being carried.

    a. Balance Point
    b. Seesaw Center
    c. Center of gravity
    d. Fulcrum Point

4. Factors that would cause a forklift to become unstable include:

    a. Carrying a load too high
    b. Tilting a forklift too much
    c. Driving on decline
    d. All of the above

5. Operators should inspect their forklifts before and after each shift.

    True or False?

6. It is safe to give someone a ride on your forklift

    True or False?

7. You can place your hand and feet outside of the operator's compartment as long as your head and body are protected.

    True or False?

8. If your truck starts to tip over, jump out immediately.

True or False?

9. When traveling across isles or around blind corners:

a. Yell "Coming Through"
b. Slow down and honk the horn
c. Look in all directions
d. B and C

10. The load capacity of the truck can be found on its data plate

True or False?

11. You can stand under the forks if the engine of the forklift is turned off.

True or False?

12. Before loading and unloading a trailer at a loading dock, you should:

a. Inspect the trailer's floor to ensure it will support the lift truck and the load
b. Chock the wheels of the trailer
c. Ensure dock plates, boards, and ramps are in place
d. All of the above

13. When transporting a load, you should not raise your forks more than 2-4 inches from the ground.

True or False?

14. Off-center loads must NEVER be handled by a forklift.

True or False?

15. When parking or leaving your truck, you should:

a. Park or leave your truck in a safe area away from traffic.
b. Lower the forks until they are flat on the floor.
c. Turn off the engine.
d. Set the parking brake and set the directional control to neutral.
e. All of the above.

16. If the lift mechanism on your fork lift fails, you should try to repair the chains or hydraulic system yourself.

True or False?

17. When charging a forklift battery, always:

    a. Ensure you are fully trained in the procedures.
    b. Wear personal protective equipment.
    c. Set the brake before starting.
    d. All of the above.

18. Which of the following should you NOT do during the refueling or recharging process?

    a. Park your lift truck in a designated refueling/recharging area.
    b. Do not block doorways or access to production or emergency equipment.
    c. Keep a flame burning nearby to burn off unwanted vapors or gases.
    d. Check to see that there is a fire extinguisher nearby.

19. The most important safety device on your lift truck is:

    a. Seat Belt
    b. Warning Light
    c. Backup Alarm
    d. YOU

Employee Acknowledgment

This is to acknowledge that I have reviewed the Forklift Operator Training. I will familiarize myself with its contents and direct any questions to my supervisor. I will also report all accidents, injuries, potential safety hazards, safety suggestions, and health and safety-related issues to my supervisor immediately. I understand that this handbook provides the high points of the information I will need to know for obtaining forklift certification as outlined by the Occupational Safety and Health Administration but is not a placement for a certified forklift operations course.

My signature certifies that I have been through forklift training and taken the quiz at the end of the course.

Employee's Signature ____________________________ Date ______________

Company _______________________________________

Course Instructor/s Signature ______________________

Appendix IV: Potential Alcohol Chart

Potential Alcohol

The actual quantity of alcohol produced by fermentation is dependent on the individual yeast strain and fermentation environment. Some amount of sugar is used by yeast to produce other compounds, and some alcohol volatilizes during fermentation. The theoretical yield of alcohol from sugar after alcoholic fermentation is 51.1% based on molecular weights and the equation of fermentation (Chapter 9). However, given the myriad of variables influencing this concentration, historical evidence shows that it is closer to 47% but can vary widely from fermentation to fermentation.

There are five Potential Alcohol (PA) columns given in the table below:

1. The first is commonly used in amateur home winemaking books (PA = 0.6×Brix** - 1).

2. The second is based on a formula given in *Progressive Winemaking* (P. Duncan & B. Acton, G.W. Kent Inc, 18th impression 1991) where, instead of the often-quoted 7.36 (or 7.4) factor to divide gravity drops by to obtain alcohol by volume values, the factor is calculated based on the initial gravity (F=7.75 - ((3×original gravity)/800))).

3. The third method uses the rebased alcohol yield of 51.1% by weight of the sugar content of the must and is calculated based on the Brix value (%abv = Brix×0.59).

4. The fourth method assumes an alcohol yield of 43% by weight of the sugar content of the must and is calculated based on the Brix value (%abv = Brix×0.43).

5. The fifth method accounts for 3 degrees Brix (0.021 degrees specific gravity) worth of non-sugar solutes and 51.1% by weight alcohol yield. It has been somewhat popularized by UC Davis.

**Brix is calculated based on the relationship: Brix = 220×(Specific Gravity - 1) + 1.6

SG	Gravity	Brix	Baumé	Sugar	Sugar (lb&oz/US gal.)		Sugar (lb&oz/Imp. gal.)		PA 1 (%)	PA 2 (%)	PA 3 (%)	PA 4 (%)	PA 5 (%)
(degrees)	(degrees)	((SG-1)×220)+1.6		g/l	lb	oz	lb	oz	0.6Br-1	F=7.36	Br×0.59	Br×0.54	PA=((Brix-3)×SG)×0.59
1.000	0	1.6	0.0	4	0	1	0	1	0.0	0.0	0.9	0.9	0
1.005	5	2.7	0.7	17	0	2	0	3	0.6	0.7	1.6	1.5	0
1.010	10	3.8	1.4	30	0	4	0	5	1.3	1.4	2.2	2.1	0.5
1.015	15	4.9	2.1	44	0	6	0	7	1.9	2.0	2.9	2.6	1.1
1.020	20	6.0	2.8	57	0	8	0	9	2.6	2.7	3.5	3.2	1.8
1.025	25	7.1	3.5	70	0	9	0	11	3.3	3.4	4.2	3.8	2.5
1.030	30	8.2	4.2	83	0	11	0	13	3.9	4.1	4.8	4.4	3.2
1.035	35	9.3	4.9	97	0	13	0	16	4.6	4.8	5.5	5.0	3.8
1.040	40	10.4	5.6	110	0	15	1	2	5.2	5.4	6.1	5.6	4.5
1.045	45	11.5	6.2	123	1	0	1	4	5.9	6.1	6.8	6.2	5.2
1.050	50	12.6	6.9	136	1	2	1	6	6.6	6.8	7.4	6.8	5.9
1.055	55	13.7	7.5	149	1	4	1	8	7.2	7.5	8.1	7.4	6.7
1.060	60	14.8	8.2	163	1	6	1	10	7.9	8.2	8.7	8.0	7.4
1.065	65	15.9	8.8	176	1	7	1	12	8.5	8.8	9.4	8.6	8.1
1.070	70	17.0	9.4	189	1	9	1	14	9.2	9.5	10.0	9.2	8.8
1.075	75	18.1	10.1	202	1	11	2	0	9.9	10.2	10.7	9.8	9.6
1.080	80	19.2	10.7	215	1	13	2	2	10.5	10.9	11.3	10.4	10.3
1.085	85	20.3	11.3	228	1	14	2	5	11.2	11.5	12.0	11.0	11.1
1.090	90	21.4	11.9	242	2	0	2	7	11.8	12.2	12.6	11.6	11.8
1.095	95	22.5	12.5	255	2	2	2	9	12.5	12.9	13.3	12.1	12.6
1.100	100	23.6	13.1	268	2	4	2	11	13.2	13.6	13.9	12.7	13.4
1.105	105	24.7	13.7	282	2	6	2	13	13.8	14.3	14.6	13.3	14.1
1.110	110	25.8	14.3	295	2	7	2	15	14.5	14.9	15.2	13.9	14.9
1.115	115	26.9	14.9	308	2	9	3	1	15.1	15.6	15.9	14.5	15.7
1.120	120	28.0	15.5	321	2	11	3	3	15.8	16.3	16.5	15.1	16.5
1.125	125	29.1	16.0	335	2	13	3	6	16.5	17.0	17.2	15.7	17.3
1.130	130	30.2	16.6	348	2	14	3	8	17.1	17.7	17.8	16.3	18.1
1.135	135	31.3	17.1	361	3	0	3	10	17.8	18.3	18.5	16.9	19.0
1.140	140	32.4	17.7	374	3	2	3	12	18.4	19.0	19.1	17.5	19.8
1.145	145	33.5	18.3	387	3	4	3	14	19.1	19.7	19.8	18.1	20.6
1.150	150	34.6	18.8	401	3	6	4	0	19.8	20.4	20.4	18.7	21.4
1.155	155	35.7	19.4	414	3	7	4	2	20.4	21.1	21.1	19.3	22.3
1.160	160	36.8	19.9	427	3	9	4	4	21.1	21.7	21.7	19.9	23.1

References

Cover

Retro bottle labels Vector Images, Royalty-free Retro bottle labels Vectors: Depositphotos®. Depositphotos. (0AD). https://depositphotos.com/vector-images/retro-bottle-labels.html.

Chapter 1

1. WorkSafeBC. (2018, January). *Health and Safety for Wineries and Vineyards*. WorkSafeBC. https://www.worksafebc.com/en/resources/health-safety/books-guides/health-and-safety-for-wineries-vineyards?lang=en.

2. Graphic Products Staff. (0AD). *Winery Safety: Common Violations and How to Stay Safe*. WINERY SAFETY: COMMON VIOLATIONS AND HOW TO STAY SAFE. https://www.graphicproducts.com/articles/winery-safety-common-violations-and-how-to-stay-safe/.

3. SafeWork SA. (2020, September 8). *Vineyards & Wine*. https://www.safework.sa.gov.au/industry/agriculture/vineyards-and-wine.

Chapter 2

1. Coetzee, C. J., & Lombard, S. G. (2013). The destemming of grapes: Experiments and discrete element modelling. *Biosystems Engineering*, *114*(3), 232–248. https://doi.org/10.1016/j.biosystemseng.2012.12.014

Chapter 3

1. Sipowicz, M. (0AD). *Winery Cleaning and Sanitation*. Texas Cooperative Extension. http://agrilife.org/winegrapes/files/2015/11/Sanitation-Guide.pdf.

Chapter 4

1. Winery Equipment & Wine Making Supplies - The Vintner Vault. (0AD). http://thevintnervault.com/.

2. *Automatic Dosing Hoppers: Grape Hopper*. Criveller Group. (2015, September 22). https://www.criveller.com/products/winery/crush-equipment/hoppers/automatic-dosing-hoppers/.

3. *Grape sorting table after de-stemming by PMH Vinicole*. PMH Vinicole manufacturer of wine pumps and winery equipment. (2019, August 23). https://www.pmh-vinicole.fr/en/grape-sorting-table.html.

4. *VitiSort Wine Grape Sorter - Key Technology*. (0AD). https://www.key.net/en/products/vitisort-wine-grape-sorter/.

5. *Bucher Vaslin. - Pneumatic presses*. Bucher Vaslin. https://www.buchervaslin.com/en-bucher-france-bucher-pneumatic-presses-16-22-26.html.

6. *Bucher Vaslin*. Products - Grape-presses - Bucher & Sutter - Bucher JLB - Basket presses. (0AD). https://www.buchervaslin.com/en-bucher-france-bucher-jlb-basket-presses-16-22-28.html.

7. *Winery Chillers: Wine Glycol Chillers*. G&D Chillers. (2021, January 29). https://gdchillers.com/applications/wineries/.

8. *HotCart - Compact Tankless Hot High Pressure Washer*. AaquaTools. (2020, December 28). https://aaquatools.com/products/pressure-washers/hotcart-propane-pressure-washer/.

9. Glacier Tanks. (0AD). *Rotating CIP Spray Ball: Tri Clamp 2 in. x 12 in. TTW w/ 1.75 in. Ball - SS304*. Glacier Tanks. https://www.glaciertanks.com/bargain-sb-g200-100-b175-12.html?gclid=Cj0KCQiAhZT9BRDmARIsAN2E-J0f2wxpO0tSlTI5pED784GeyGrA92NBiHPxgdARAhiEuRA48c1NBd8aAmOUEALw_wcB.

10. *Uline Pallet Truck - Narrow Fork, 48 x 21" H-1193*. Uline. (0AD). https://www.uline.com/Product/Detail/H-1193/Pallet-Trucks/Uline-Pallet-Truck-Narrow-Fork-48-x-21?pricode=WA9043&gadtype=pla&id=H-1193&gclid=Cj0KCQiAhZT9BRDmARIsAN2E-J0AeH72mvP9tLO5DD4ejNBDbTaiSxk7SaPyCz4riRDzXEemnq919Y8aAghZEALw_wcB&gclsrc=aw.ds.

11. *Wine Equipment Supplier: Carlsen & Associates*. Carlsen and Associates. (0AD). https://carlsenassociates.com/.

12. *Balthazar HD Winery Hose: Tri Clamp 1.5 in. x 5 ft. @ 250 PSI - NBR / EPDM / UHMWPE / 3A - Purple*. Glacier Tanks. (0AD). https://www.glaciertanks.com/heavy-duty-winery-hose-txl-wnhd-1.5-5.html.

13. *Sanitary Male Threaded Ferrule Pipe Fittings*. Amazon.com. (0AD). https://www.amazon.com/Dernord-Sanitary-Threaded-Tri-clamp-Tri-clover/dp/B07CSW5VRD.

14. *DIN Fittings - Thomas Potter Ltd*. Thomas Potter. (0AD). http://www.thomaspotter.com/din-fittings.

15. *Fitting & Valves*. Davison Winery Supplies. (0AD). https://dwinesupplies.com/collections/fitting-valves/butterfly-valve.

16. *Racking Wand*. Lodi Wine Labs. (0AD). https://www.lodiwinelabs.com/products/racking-wand-fermentap.

17. *BULLDOG PUP*. Davison Winery Supplies. (0AD). https://dwinesupplies.com/products/bulldog-pup.

18. *Stainless Tri-Clamp Rotating Racking Arm - 1.5 in.* Keg Factory. (0AD). https://kegfactory.com/products/

19. *Carbonation Stone: Tri Clamp 1.5 in. x 8 in. x FNPT 1/4 in. - SS316*. Glacier Tanks. (0AD). https://www.glaciertanks.com/tank-carbonation-stones-cbst-800.html.

20. H, S. (2018, January 23). *Wine Cap Punch Down Tool - With Handles (72" Tall) reviews summary*. MoreWineMaking! https://morewinemaking.com/products/wine-cap-punch-tool-handles-72-tall.html.

21. *Sheet filters*. dellatoffola.us. (0AD). https://www.dellatoffola.us/en/catalogue/winemaking-division/wine-filtering/plate-filters-/sheet-filters.

22. *Bucher Vaslin Flavy Cross Flow*. Gusmer Enterprises. (0AD). https://www.gusmerwine.com/catalog/cross-flow-filtration/bucher-vaslin-flavy-cross-flow-filter/.

23. *Cartridge Filter Housing AISI 316 Stainless Steel*. Winemakers Depot. (0AD). https://www.winemakersdepot.com/Cartridge-Filter-Housing-AISI-316-Stainless-Steel-P1465.aspx.

24. *MOVIRO reverse osmosis systems for wine*. dellatoffola.us. (0AD). https://www.dellatoffola.us/en/catalogue/winemaking-division/Clarification-must-enrichment/reverse-osmosis/reverse-osmosis-systems.

25. *Centrifuges - The Vintner Vault*. The Vintner Vault. (0AD). http://www.thevintnervault.com/category/586/Centrifuges.html.

26. *Technical Data Sheet & Catalogues Mixing*. INOXPA. (0AD). https://www.inoxpausa.com/downloads/documents/mixing.

27. OrchardValleySupply.com. (0AD). *Harvest Lugs*. OrchardValleySupply.com. https://www.orchardvalleysupply.com/collections/harvest-lugs.

28. *Macro Bin - Half Ton*. MoreWineMaking! (0AD). https://morewinemaking.com/products/macro-bin-ton.html.

29. *Cole-Parmer 0.690/0.800 Specific Gravity Hydrometer for Liquids Lighter Than Water*. Cole Parmer. (0AD). https://www.coleparmer.com/i/cole-parmer-0-690-0-800-specific-gravity-hydrometer-for-liquids-lighter-than-water/0829811.

30. *Dual Scale Refractometer With Light & ATC*. William's Brewing. (0AD). https://www.williamsbrewing.com/Home-Brewing-Equipment/Testing-Equipment/Hydrometers-Refractometers/-Dual-Scale-Refractometer-With-Light-ATC.

31. *Anton Paar DMA 35 0.0001 g/cm3 Resolution Portable Density Meter, with Infrared Interface*. Amazon.com. (0AD). https://www.amazon.com/Anton-Paar-DMA-35-Resolution/dp/B007Y9SNCW.

Chapter 5

1. Gravity Wine House. (2018, July 22). *Wine Production: A Brief Guide to Pumps of the Wine World*. Gravity Wine House. https://gravitywinehouse.com/blog/wine-production-a-brief-guide-to-pumps-of-the-wine-world/.

Chapter 6

1. Donahue, C. (2019, March 2). *Differences Between a Ball Valve & a Butterfly Valve*. Sciencing. https://sciencing.com/list-6722176-differences-ball-valve-butterfly-valve.html.

2. Winery Equipment & Wine Making Supplies - The Vintner Vault. (0AD). http://thevintnervault.com/.

3. *Grapes love our tanks*. ICC Northwest. (0AD). https://icc-nw.net/wine/.

Chapter 7

1. Williams, D. R. (2020, November 25) https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html

2. Zoecklein, B. (n.d.). *GASES: CARBON DIOXIDE, ARGON, AND NITROGEN*. Virginia Tech Enology. https://www.apps.fst.vt.edu/extension/enology/downloads/wm_issues/Winery%20Gases/Winery%20Gases2.pdf.

3. Rotter, B. (0AD). *Sulphur Dioxide*. Improved Winemaking: Sulphur Dioxide. http://www.brsquared.org/wine/Articles/SO2/SO2.htm.

4. Mats, Granvik, & Roger, Bagula. (1964, February 1). *What is the CO2 content in the air in a compartment of air and water, as a function of temperature?* Chemistry Stack Exchange. https://chemistry.stackexchange.com/questions/28879/what-is-the-co2-content-in-the-air-in-a-compartment-of-air-and-water-as-a-funct.

5. *High-Pressure Cylinders*. Air Liquide USA. (2016, October 4). https://industry.airliquide.us/high-pressure-cylinders.

Chapter 8

1. Chidi, B. S., Bauer, F. F., & Rossouw, D. (2018). The Impact of Changes in Environmental Conditions on Organic Acid Production by Commercial Wine Yeast Strains. *South African Journal of Enology and Viticulture*, *39*(2). https://doi.org/10.21548/39-2-2820

2. Boulton, R., Bisson, L., Kunkee, R., & Singleton, V. (1996). *Principles and practices of winemaking*. Chapman&Hall.

3. Killian, E., Ough C.S., (1979). Fermentation Esters - Formation and Retention as Affected by Fermentation Temperature. *American Journal of Enology and Viticulture*, *30*, 301–305.

4. Mansneuf-Pomadre, I., Mansour, C., Murat, M., Tominaga, T., & Dubourdieu, D. (2006). Influence of fermentation temperature on volatile thiols concentrations in Sauvignon blanc wines. *International Journal of Food Microbiology*, *108*, 385–390. https://doi.org/10.1016/j.ijfoodmicro.2006.01.001

5. Molina, A. M., Swiegers, J. H., Varela, C., Pretorius, I. S., & Agosin, E. (2007). Influence of wine fermentation temperature on the synthesis of yeast-derived volatile aroma compounds. *Applied Microbiology and Biotechnology*, *77*(3), 675–687. https://doi.org/10.1007/s00253-007-1194-3

6. Torija María Jesús, Beltran, G., Novo, M., Poblet, M., Guillamón, J. M., Mas, A., & Rozès, N. (2003). Effects of fermentation temperature and Saccharomyces species on the cell fatty acid composition and presence of volatile compounds in wine. *International Journal of Food Microbiology*, *85*(1-2), 127–136. https://doi.org/10.1016/s0168-1605(02)00506-8

7. Valentine, G. D. S., Walker, M. E., Gardner, J. M., Schmid, F., & Jiranek, V. (2018). Brief temperature extremes during wine fermentation: effect on yeast viability and fermentation progress. *Australian Journal of Grape and Wine Research*, *25*(1), 62–69. https://doi.org/10.1111/ajgw.12365

8. Ough, C. S. (1964). Fermentation rates of Grape Juice. I. Effects of Temperature and Composition on White Juice Fermentation Rates C.S. Ough. *American Journal of Enology and Viticulture*, *15*, 167–177.

Chapter 9

1. Producing Ethanol by Fermentation: Easy exam revision notes for GSCE Chemistry. (0AD). http://www.passmyexams.co.uk/GCSE/chemistry/producing-ethanol-by-fermentation.html.

2. Hemphill, R. (0AD). *Yeast for Winemaking*. Wines and Winemaking. https://www.winesandwinemaking.com/yeast.php.

3. *How to measure Specific Gravity using a Homebrew Hydrometer*. The HomeBrew Forum. (0AD). https://www.thehomebrewforum.co.uk/threads/how-to-measure-specific-gravity-using-a-homebrew-hydrometer.60895/.

4. *Brewing Science-Yeast*. SlidePlayer. (0AD). https://slideplayer.com/slide/9935840/.

5. *Problem Fermentations*. UC Davis Viticulture and Enology. (2018, April 6). https://wineserver.ucdavis.edu/industry-info/enology/fermentation-management-guides/wine-fermentation/problem-fermentations.

6. Setford, P. C., Jeffery, D. W., Grbin, P. R., & Muhlack, R. A. (2017). Factors affecting extraction and evolution of phenolic compounds during red wine maceration and the role of process modelling. *Trends in Food Science & Technology*, *69*, 106–117. https://doi.org/10.1016/j.tifs.2017.09.005

7. Siddall, L. (2021, February 15). *What is Malolactic Fermentation?* Matthew Clark. https://www.matthewclark.co.uk/latest-news-blog/blog/what-is-malolactic-fermentation/.

8. Wikimedia Foundation. (2020, December 9). *Malolactic fermentation*. Wikipedia. https://en.wikipedia.org/wiki/Malolactic_fermentation#/media/File:MLF_spotting_sheet_with_acids_noted.png.

9. Jiranak, V. (2010, September 2). *Wine Microbiology for Fermentation Success and Wine Quality*. SlideShare. https://www.slideshare.net/Waite/wine-microbiology-for-fermentation-succes.

Chapter 10

Pregler, B. (0AD). Product Review: Barrel Washers. https://www.winebusiness.com/wbm/?go=getArticleSignIn&dataId=48463.

10 MOST COMMON OAK CASK DIMENSIONS, SIZES, VOLUMES AND TYPES. COGNAC DAILY NEWS Estd 2011. (2016, September 15). https://cognacs.wordpress.com/2016/09/15/10-most-common-oak-cask-dimensions-sizes-volumes-and-types/.

Glossary

1. *Winemaking Terms*. VINEX. (n.d.). https://en.vinex.market/support/glossary/winemaking-terms.

Appendix III Forklift Training

1. Iowa Automotive Recyclers. (0AD). *Forklift Operator Training Handbook*. http://docshare02.docshare.tips/files/18430/184304964.pdf.

2. State of Washington. (2007, April). *Forklift Safety Guide*. Washington Department of Labor and Industries. https://depts.washington.edu/wineryhs/Content/Forklift%20Safety%20Guide.pdf.

3. Hinz, P. (2013). *Forklift Speed Limits and Braking in the Warehouse*. Adaptalift. https://www.adaptalift.com.au/blog/2013-02-01-forklift-speed-limits-and-braking-in-the-warehouse.

4. Oregon OSHA. (2004). *Forklift Safety*. Oregon Environmental Health and Safety. https://ehs.oregonstate.edu/sites/ehs.oregonstate.edu/files/pdf/occsafety/or-osha_forklift_instructors_guide.pdf.

5. Government of Canada. (2021, March 18). *Forklift Trucks - Daily Checks*. Canadian Centre for Occupational Health and Safety. https://www.ccohs.ca/oshanswers/safety_haz/forklift/checks.html.

Appendix IV- Potential Alcohol Chart

1. *Technical Winemaking Information*. Frankston Amateur Winemaker's Guild . (0AD). http://www.fawg.org.au/documents/SG%20TABLE.pdf. Article reproduced from brsquared.org/wine (©Ben Rotter)

Recommended References

For those interested in the more technical side of wine production, the following texts are recommended as an integral part of every wine science library:

Waterhouse, A., Sacks, G., & Jeffery, D. (2016) Understanding Wine Chemistry. John Wiley & Sons Ltd.

Zoecklein, B., Fugelsang, K., Gump, B., and Nury, F. (1999) Wine Analysis and Production. Aspen Publications

Jackson, R. S. (2020). *Wine science: principles, practice, perception* (5th ed.). Academic Press, an imprint of Elsevier.

Iland, P. (2012). *Monitoring the winemaking process From grapes to wine: techniques and concepts*. Patrick Iland Wine Promotions.

Moreno-Arribas, M. V., & Polo, M. C. (2010). *Wine chemistry and biochemistry*. Springer.

Ribéreau-Gayon Pascal, Dubourdieu, D., Donèche Bernard, Lonvaud-Funel, A., Glories, Y., Maujean, A., & Towey, J. (2020). *Handbook of enology* (3rd ed., Vol. 1 & 2). Wiley.

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