The end of August is a good time to inspect the winery. Botrytis rot. Photo by Turner Sutton

Preharvest Planning

Harvest is fast approaching, like it or not. With some careful planning, harvest does not have to be chaotic. Now is the time to go back and look at the 2020 harvest and identify areas needing improvement. Clean up the clutter and determine what needs to be replaced. Resolve any pest issues and check the refrigeration system. Is the water quality adequate? If not get it serviced now. For worker safety, install CO\textsubscript{2} sensors if you do not have them already.

If you are purchasing fruit, have all contracts in place. Have the grower provide a crop estimate so that you can plan accordingly. Request berry parameters (Brix, pH, TA) be sent regularly as harvest approaches. Also, confirm if the fruit will be delivered to your winery or picked up. Visit the vineyard regularly and be sure to convey expectations. Examine all fruit for ripeness and any rot or insects present.

In preparation for crush, consider three main areas: the crush pad, fermentation cellar, and barrel room. Within each of these areas, pre-crush tasks can be divided into four areas: planning, corrective maintenance, preventative maintenance, and lastly sanitation. Of this list, sanitation is definitely of high importance.

While planning, consider a baseline workflow for receiving, crushing, pressing, and fermenting the grapes. Start with a basic white and a basic red plan. You can add more details as harvest goes on. This also allows new employees or harvest interns to know what to expect next in the process. I also recommend a HACCP plan (Hazard Analysis and Critical Control Points). This involves looking at the production process from start to finish. This can be in a flowchart format. You then identify where hazards can occur and put in controls and monitor them routinely. For example, at the end of fermentation measure the volatile acidity, have an acceptable level, list how to address it if too high. Continue to monitor throughout the winemaking process and keep good records.

Make sure to know approximate harvest yields and determine the tank/barrel capacity needed. For whites, you will need 210 gallons of tank space per ton of fruit. Red fermentations on the skins will need 250 gallons per ton. Storage gallons for both will be approximately 165 gallons per ton.

In the winery, have your cooling system checked, inventory barrels, and identify leakers. All equipment should be tested including scales, crusher/de-stemmer, pumps, press, and forklift several weeks before harvest. Remember to inventory all wine. What do you still have an abundance of in inventory? Maybe it is time to re-evaluate plans to produce those wines this harvest.

On the crush pad, make sure that bins are cleaned. Know where grapes will be stored, if needed, when they arrive. Do you need to arrange for a refrigerated truck rental? In addition, have a plan for how pomace will be disposed of. It is imperative that pomace be as far away from the winery as possible. You will certainly have a fruit fly infestation if it is close to the winery.

This is by no means a complete list but please refer to the list below of common chemicals and supplies that you may need.

- Yeast
- Sulfur dioxide (potassium metabisulfite)
- Acids (tartaric, citric)
- Rice and yeast hulls
- Enzymes
- Tannins
- Gas cylinders
- Lysozyme?
- Sugar
• ML culture
• Yeast nutrients
• Diammonium phosphate or other N sources
• Fining agents (bentonite, isinglass, PVPP)
• Filter pads (stacked pad, sterile cartridge)
• Cleaning supplies

Don’t forget to order lab supplies if you will be performing tests in-house. If you will be sending samples to a reference lab, have enough sample containers, labels, and shipping boxes on hand. Some basic things that you may be measuring include:

• YAN
• pH—replace probe every 2 years or as needed
• TA
• Brix—have extra hydrometers on hand
• SO₂
• VA
• MLF
• Alcohol

Some additional equipment considerations:

• Check all equipment is in functioning order and service if needed
• Do you need to rent an extra forklift?
• Do you have an extra pump/press on hand?
• I recommend going through a dry run to ensure that you haven’t missed anything
• Clean and sanitize everything
• Know your neighbors. Can you ask to borrow supplies if needed?
• Have spare parts on hand for minor repairs

Consider your staffing needs. Have standard operating procedures (SOPs) for everything to make sure that each protocol is being done exactly the same by all employees and provide necessary training. Have personal protective equipment (PPE) on hand to provide a safe work environment. Material safety data sheets (MSDS) should be available for every chemical in the winery. Information contained in the MSDS includes precautions to be taken when using a chemical and what to do in case of exposure.

**Winery Sanitation**

Proper winery sanitation is absolutely the most important aspect of quality wine production. Wine is an acid food (low pH). This combined with the ethanol that it contains makes wine unable to support the growth of human pathogens. According to the Federal Drug Administration (FDA), a winery is a food processing facility and subject to federal regulations, especially Good Manufacturing Practices (GMPs) listed in Title 21 CFR 110. These regulations include sanitation and processing requirements for the production of safe food.

First, we will introduce some definitions used in a sanitation program: cleaning, sanitizing, and sterilizing. Knowing the differences among these will enable a winery to implement a more effective sanitation plan.

**Cleaning:** Removing of mineral or organic matter, and debris from surfaces (normally using detergents). This step also eliminates environments conducive to the growth of spoilage organisms.

**Sanitizing:** Reduction of the microbial population to a safe or acceptable level (kills 99.99%) of organisms. **Note:** You cannot sanitize a dirty surface!

**Sterilizing:** Provides 100% kill of viable cells including spores.

General steps in cleaning and sanitizing include:

1. Removal of debris without water. This may include removal of rachises and leaves from the crusher/destemmer missed last year.
2. Pre-rinse to remove some organic debris that is not tightly bound.
3. Use of detergent, usually alkaline in nature. This will remove organic material such as proteins.
4. Rinse
5. Use of a sanitizer, usually acidic in nature. This will remove inorganic matter such as metallic residues and alkaline residues not removed during cleaning with detergent.
6. Rinse (may not be needed with certain sanitizers)

Some areas/sources that are prone to a build-up of spoilage organisms include:

• The vineyard: fruit may come in from the vineyard with rot or insects
• Diluted pools of juice on the crush pad or in the winery
• Second-hand barrels: know your source
• Imported bulk wine
• Areas of the winery that are difficult to reach
• Fruit flies: capable of carrying spoilage organisms throughout the winery
• Wine thief: sanitize or sterilize between each barrel using 70% alcohol. A presentation from Cornell included the suggestion that a thermos with >185°F water would result in an instant kill of organisms when thief was dipped between barrels.

There are a number of factors involved in determining how likely it is for spoilage organisms to thrive including:

• Oxygen: acetic acid bacteria and others grow best in the presence of oxygen
• Temperature: the warmer the temperature (to a certain point) encourages organisms to grow. Lower temperatures inhibit their growth.
• Alcohol: the higher the alcohol, the greater the inhibition of organisms
• Molecular SO$_2$: this is the free form of SO$_2$ that is the antimicrobial form
• pH: the lower the pH the less chance of microbial growth. As pH approaches 4.0, the greater the chance of microbial growth.
• Nutrient status: if there is a nutrient source present, other spoilage organisms can grow

Some of the microbes that may grow during fermentation include non-Saccharomyces yeasts, lactic acid bacteria, and acetic acid bacteria. In order to detect the presence of these organisms, you should monitor for the following:

• Ethyl acetate
• Spontaneous or sluggish fermentation
• Spontaneous malolactic fermentation
• Volatile acidity
• 4-ethyl phenol and 4-ethyl guaiacol
• Sulfur-like off odors
• Other off odors

As a rule of thumb, acid cleaners dissolve alkaline soils (minerals). Alkaline cleaners dissolve acidic soils and food wastes (proteins). The improper use of detergents can actually “set” soils, making them more difficult to remove (e.g. acid cleaners can precipitate proteins).

It is a common misconception that “if a little is good, more is better”. Using sanitizer concentrations above recommendations does not make sanitizer perform better. In fact, this can corrode equipment. Always follow manufacturer label instructions.

Cleaners

Prior to using detergents to clean, apply a warm (100-109°F), high-pressure rinse (600-1200 psi). Avoid the use of hot water that can “bake on” debris. Once the visible debris is removed, detergents are used to solubilize remaining deposits. Detergents include alkalies, acids, surfactants, and rinses.

Alkalies are excellent detergents and include caustic soda (NaOH) and caustic potash in the pH range of 12.0 to 14.0. They work well on tartrates and have strong antimicrobial properties. Care must be taken when using them including the use of proper personal protective equipment (PPE). If used too concentrated, they will corrode stainless steel. There are milder alternatives such as sodium carbonate (soda ash) or trisodium phosphate (TSP) in the pH range of 10.0-11.5. The alkaline compounds kill cells by stripping the cell membrane of yeast and bacteria.

Acid detergents reduce mineral deposits and also soften water. The pH is between 1.5 and 3.5. These can also be corrosive to metals such as stainless steel. An example is phosphoric acid.

Surfactants lower the surface tension between a liquid (water-containing detergent) and a solid (debris) making the dirt more soluble and easier to remove. One end of the surfactant is hydrophilic (water-loving) and the other end is hydrophobic (water-repelling).

After cleaning with detergents, a rinse may be required. For example, a mild acid rinse (citric) can be used to neutralize alkaline residues

Sanitizers

Once thoroughly clean, a surface can then be sanitized. Sanitizers work by lysing cell membranes, blocking membrane functions (e.g. waste removal), and inactivating key enzymes. There are some combined cleaner/sanitizers but a sanitation step is still required. It is vital to make sure the surface is clean since sanitizers will preferentially bind to organic matter.

Some examples are listed below and their use briefly discussed:

• Acidulated sulfur dioxide
• Halogens
• Quaternary ammonium compounds (QUATS)
• Iodine
• Hot water and steam
• Peroxides
• Peracetic/hydrogen peroxide
• Ozone
• Ethanol (70%)/80 proof vodka

Acidulated sulfur dioxide

This sanitizer has antimicrobial activity which is pH-dependent (3.0-4.0). In acidulated cold water (pH below 3.5) more SO$_2$ will be in the molecular form. Use 100 ppm SO$_2$ (200 ppm potassium metabisulfite and 3 g/L citric acid, or enough to achieve a pH below 3.5). It is good for sanitizing hoses and in closed systems.

Halogens

Chlorine-containing (sodium and calcium hypochlorite) compounds are halogens and are not recommended except for out-of-control microbial situations. They act as precursors in the microbial formation of trichloroanisoles (TCA). Chlorine dioxide is a broad-spectrum antimicrobial and is effective in destroying biofilms. Chlorine is not a by-product therefore TCA is not a concern

Iodine

The iodophors also have a broad spectrum of activity against microorganisms. At a concentration of 25 ppm, pH<4.0 it is active against bacteria, viruses, yeasts, and molds. Iodine can be used to sanitize bottling lines followed by a cold rinse. There may be the potential for the formation of TCA.
Quaternary ammonium compounds (QUATS)

QUATS are a cationic (positively charged) surfactant. At a concentration of 200 ppm, they damage cell membranes of microorganisms (lactic acid bacteria more so than acetic acid bacteria). They leave a residual antimicrobial film if unrinsed. They can be used on floors and walls and other non-product contact areas.

Hot water and Steam

Hot water and steam are strong antimicrobials at >180°F for no less than 20 minutes. They may degrade gaskets but are non-corrosive. Their main use is the sterilization of bottling lines and for barrel sanitation (140-176°F using high pressure). At temperatures between 170°F and 185°F, there is an instant kill of microorganisms.

Peroxides

Hydrogen peroxide breaks down to superoxide oxygen (O₂⁻). Peroxides are very effective antimicrobials but less so against spores and wild yeasts. Peroxyacetic acid (PAA) combines peracetic acid and hydrogen peroxide that works synergistically to kill 99.99% of microbes. At the diluted concentrations (2.5-15%) it leaves low residual PAA (3-5 ppm), requiring no rinse. A strong oxidizer, PAA can be used to sanitize many surfaces including barrels and bottling line sanitation. Concentrated solutions are corrosive, but diluted, it is also environmentally friendly, breaking down to acetic acid, water, and oxygen.

Percarbonates and Soda ash (sodium carbonate)

Per(oxy)carbonates are a stabilized powder with hydrogen peroxide. Oxygen radicals are released via hydrogen peroxide. This alkaline product degrades to soda ash, water, and oxygen. It is commonly used on barrels but, due to their porous nature, 100% kill is not achieved.

Soda ash is a strong alkaline compound. It dissolves proteins, fats, oils, and carbohydrates. It also works well on tartrates. It can also neutralize odors associated with volatile acidity.

Ozone (O₃)

Ozone is a potent sanitizer but is not a cleaner. It is a hyper-radical of oxygen that has strong oxidizing properties. It can be dissolved in water or applied as a gas. It has a shorter half-life in water (seconds) compared to gas (24 hours). If water is used, it must be generated on demand by exposing a stream of dry air to an electrical discharge. It is active against bacteria, fungi and spores. Be sure to check gasket compatibility as ozone can degrade certain ones. Ozone is a strong irritant so train staff and have proper safety monitors in place.

For barrels, the following protocol is suggested:

- Perform high-pressure cold wash
- Follow with hot water or steam
- Cool rinse 2-3 minutes
- Rinse with ozonated water (filtered water since minerals limit ozone effectiveness)
- Follow manufacturer’s suggested contact time/concentration

Other

Additional sanitizing options include:

- UV light
- Dry ice blasting for barrels
- High power ultrasound for barrels

Hoses, valves, and fittings

When sanitizing fittings, consider soaking in a solution. For example, an alkaline cleaner followed by a citric acid rinse to neutralize. Then apply acidulated sulfur dioxide to sanitize.

Tygon™ corrugated hoses (you can see through them) are recommended. Rubber/fiber blend hoses are harder to clean and not transparent. Consider the use of foam balls to better clean hoses.

Ball valves tend to harbor more debris and microbial growth compared to butterfly valves. Take all valves apart and clean/sanitize prior to harvest. I suggest filling the tank with water when valves are replaced to make sure they don’t leak. Gaskets may need to be replaced and can be easily made with a gasket kit (use food-grade rubber).

Drains and Filters

Drains can be plugged and filled with sanitizer or hot water. I have found that peroxycarbonates followed by a citric rinse also work well.

If you choose to reuse filters, you can use a caustic/acid treatment followed by a sanitizing step. Rinse with a sanitizer before use (e.g. KMS/citric). Remember to perform an integrity test (e.g. bubble point) prior to filter use.

Barrels

Care must be taken when treating barrels as chemicals can either taint the wood or extract essence.

Some considerations for barrels:

- Don’t let them dry out
- Store with KMS/citric acid solution
- Clean the outside as well as the inside
- Recover with a percarbonate based cleaner (1 T/gal), let sit 24 hrs., rinse, rinse again with citric acid (0.5 t/gal)
Rotating Schedule
Cleaners and sanitizers should be rotated every 1-2 weeks. For example, four days a week use a caustic detergent to clean (alkaline) followed by peroxyacetic acid sanitizer. On the fifth day, use an acid cleaner to decrease mineral deposits. This will also remove deposits not removed by the alkaline cleaner. To sanitize, QUATS could be used.

Biofilms
Some microbes use nutrients from juice and wine to form polymers. Once on a surface, other bacteria will aggregate and attach. They continue to grow, forming a biofilm with a protective layer surrounding the microbes. Invisible to the naked eye, biofilms are resistant to many chemical cleaners. They usually need physical action (scrubbing, high pressure) for removal.

One suggested treatment is the use of caustics (167°F for 30 min.) followed by a citric acid rinse. Ozone has been shown to be ineffective in treating biofilms.

Sterilizers
In the winery, we typically do not achieve true sterility. Rather, we reserve “sterilization” steps for processes such as sterilization of the bottling line. Hot water and steam are normally used:
- 180°F for 20-30 min.
- Ozone for 20-30 min.

Sources of contamination at bottling include:
- Filler bowls: use steam or hot water (180-185°F) to “sterilize” (Thermal dots on the outside of filler bowl can verify temperature)
- Mist filler spouts with 70% ethanol to inhibit microbial growth
- Corker: likely to have spilled wine present. Mist jaws with ethanol during bottling.
- Activity: limit number of people in the area

Verification
- Strips are available to test the concentration of sanitizers
- Verify contact time by using a timer
- Verify the proper temperature of solutions
- Areas of the winery can be swabbed and plated on agar growth media or sent to a reference lab for culture and/or molecular testing
- Photodetectors using bioluminescence technology can be used to monitor the presence of cellular material. Surfaces are swabbed and if ATP is present (an energy-carrying molecule found in all living things), in the presence of luciferin and an enzyme, it will fluoresce. The degree of fluorescence is proportional to the number of cells present.

Basic Rules
- Clean then sanitize everything prior to use
- Clean everything after use
- Keep the winery premises clean and clutter-free
- Monitor for mold, bacteria, rodents etc.
- Deal with pomace immediately

Remember that winery sanitation will impact final wine quality. Clean then sanitize!

References
- Butzke, C., Barrel Maintenance, Dept. of Food Science, Purdue University, 2007.
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