Bulk Aging in Wine: Best Practices, Monitoring, and Troubleshooting.

Bulk aging is where wine quietly becomes what it's meant to be—or, if you're not paying attention, something you never intended. It's one of the most critical phases in winemaking, where time, chemistry, and technique all work together to shape a wine's final character.

Oak barrels, in particular, can add remarkable complexity, texture, and aromatic depth. But they're not a "set it and forget it" solution. Bulk aging—whether in oak, flex tanks, or glass carboys—requires thoughtful monitoring and occasional intervention to keep things on track and avoid unwanted surprises.

In this guide, we'll walk through how bulk aging works, what to test for along the way, and how to troubleshoot the most common issues that can arise during the process.

Our perspective comes from hands-on experience. At our sister company, Little Oaks Winery, we produced wines from North San Diego County grapes for a decade. While production ended in 2022, we're still aging and selling those wines—and still learning from them.

Our winery focused on varietals that thrive in the region: mostly Viognier for whites, and Sangiovese, Malbec, and Barbera for reds, with some Cabernet and Syrah in the early years. The whites were fermented cool at about 55°F, and left on lees for about five months after one racking, and did not undergo malolactic fermentation. The reds were fermented at room temperatures, underwent malolactic fermentation to completion, and then bulk-aged in Hungarian oak barrels for 12 to 18 months.

Along the way, we made some excellent decisions—and a few memorable mistakes. This guide is built on both.

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What Is Bulk Aging?

Bulk aging refers to storing large amounts of wine in vessels—commonly oak barrels—before bottling. As home winemakers, it is also common for bulk aging to occur in glass or PETE carboys with the addition of oak chips or spirals to help mimic the aging process using an oak barrel. During this stage, the wine evolves through:

- **Micro-oxygenation**: Small amounts of oxygen pass through the barrel or other vessel, softening tannins and stabilizing color.

- **Extraction from oak**: Compounds such as vanillin, lactones, and tannins are imparted into the wine.
- **Chemical integration**: Acids, alcohol, phenolics, and aromatic compounds harmonize over time.

Why is bulk aging important?

Bulk aging is important because the flavor and aroma profiles develop more complexity than if the wine were to be bottled right away. In addition, bulk aging allows the winemaker to monitor these parameters and to verify the wine's stability in order to make the best decision about timing its bottling.

Do your Homework!

It's also worth saying: get to know the varietals you're working with. A little homework before committing to bulk aging can go a long way in helping you decide how to handle your wine—and whether it might need any varietal-specific tweaks along the way.

Case in point: our 2013 Sangiovese. It was gorgeous—multi-award-winning, the kind of wine that makes you pause mid-sip and feel very accomplished. We produced around 150 cases, and as a new winery, those cases lingered on our shelves just a bit longer than we had planned. (Turns out "award-winning" doesn't always mean "flies off the shelf.")

Fast forward to 2015. We're pouring that same Sangiovese at a local Taste of Mainstreet event, chatting up guests, feeling proud… when suddenly—*plop*. Out of one of the bottles slides a white, snot-like glob. Not exactly the kind of tasting note you want to introduce to customers.

Naturally, it looked pretty off-putting. But here's the strange part: the wine itself still tasted fantastic—arguably even better than before. So now we had a mystery on our hands: visually horrifying, but delicious. Not ideal.

As luck would have it, less than a week later our latest issue of *WineMaker Magazine* arrived, and the cover story was all about quercetin and its effects on low-tannin wines. Lightbulb moment. Our relatively low-tannin Sangiovese had developed quercetin after extended time in bottle—something we hadn't even realized could happen.

Lesson learned.

From that point on, we started blending our Sangiovese with a higher-tannin varietal, like Malbec. Just enough to keep the wine true to its Sangiovese character, but with a little extra structural insurance to prevent another… surprise guest from showing up in the bottle.

Key Factors to Manage During Bulk Aging

1. Oxygen Exposure

Oak barrels are semi-permeable, allowing gradual oxygen ingress. While beneficial in moderation ("micro-oxidation"), too much oxygen leads to undesirable oxidation.

Glass and PETE carboys are largely impermeable to oxygen, especially once sealed after fermentation stops. Here the challenge may be to get *some* oxygen into the wine. In general though it's probably best to moderate flavors of carboy aging by additives like oak chips or extracts.

We do not recommend bulk aging in polyethylene or polypropylene tanks or carboys, like the older classic Flex Tanks. We learned the *hard way* that these are fine for short term storage and blending of wines, but their high permeability to oxygen makes SO_2 management difficult over the months needed for aging.

During one particularly ambitious harvest, we found ourselves with a great problem to have—plenty of wine—and a not-so-great reality—nowhere near enough barrels. So, in a moment of creative problem-solving (or questionable judgment, depending on how you look at it), we decided to age some of our Malbec in a flex tank. It was what we had, so we made it work… or at least, we thought we did.

We added oak spirals to help mimic barrel aging, "fixed" sensory issues when they arose, and let it sit, confident we had engineered a clever workaround. Fast forward about 15 months, and the verdict was in: the wine had not aged gracefully. In fact, it had gone decidedly the other direction.

In the back of our minds we knew the flex tanks weren't the ideal tank but we had no other choice. And just to really drive the lesson home, this wasn't a small experiment. It was a 200-gallon tank. Because if you're going to make a mistake, you might as well make it impressively.

Management tips:

- Monitor headspace and keep barrels topped up regularly (at least every 2-4 weeks)
- If possible, maintain proper humidity (60–75%) to reduce evaporation.

- Keep SO_2 levels adjusted

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2. Temperature and Humidity

Environmental conditions directly affect aging rate and wine stability.

- **Ideal temperature:** 55–60°F (13–16°C)
- **Humidity:** 60–75%

Higher temperatures accelerate aging but increase spoilage risk; low humidity causes excessive evaporation. Most important, though is that the temperature is controlled. It's much better to have your wine at 66-68°F constantly than to have it swing 55-75°F! (We also learned this the *hard way*, though we were aware of it)

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3. Sulfur Dioxide (SO_2)

SO_2 protects wine from oxidation and microbial spoilage.

- Maintain appropriate **free SO_2** based on pH.
- Check levels regularly (every 4 weeks or so) and adjust as needed.
- Keep containers properly topped off.

You can do your testing and topping off at the same time but we recommend testing your SO_2 levels first and adding the appropriate potassium metabisulfite (KMBS) before "topping off" your barrel. NOTE: if measured free SO_2 is low (under 10 ppm), then it's a good idea to re-measure it within 24 hours of any addition, because a lot of added sulfite in this case can become "bound" which is not protective.

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4. Lees and racking

Prolonged exposure of bulk wine to settled lees can produce unwanted flavors and aromas. Most winemakers rack their wine immediately after primary fermentation, then (especially for reds) once or twice more over the course of bulk aging to reduce the mass of the lees.

Essential Tests During Bulk Aging

Routine lab analysis is essential to catch problems early. The following tests should be part of your monitoring schedule:

1. Free SO_2

- Frequency: Monthly
- Purpose: Ensure microbial and oxidative protection
- Maintain free SO_2 at the correct level to hit the target *molecular SO_2* level based on pH

  Table 1. Free SO_2 concentrations necessary to attain 0.8 mg/L molecular SO_2 at a designated pH.

Free SO_2 (ppm)	13	16	21	26	32	40	50	63	79	99	125
pH	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0

  - for reds, 0.4 to 0.5 ppm molecular SO_2; whites and rosés, 0.8 ppm.
  - Use an SO_2 calculator, like that in FermCalc, to determine the right free SO_2 level, at any given pH, to hit the target molecular SO_2 value. Note that, as Table 1 shows, the protective level of free SO_2 at pH 3.0 is almost ten times less than at pH 4.0.
- *Total SO_2* levels may be required for commercial production.

2. pH and Titratable Acidity (TA)

- Testing and adjusting TA usually is done at the start of primary fermentation. If tartrate instability is apparent during bulk aging, you may need to measure/adjust TA, pH and potassium levels.
- Frequency: We recommend testing your pH at the same time that you test your SO_2 levels. If you have a near constant pH reading after several rounds of testing, you can normally assume that your pH hasn't changed much and you can simply use that pH for future SO_2 additions. Every month until stable.
- Purpose: Monitor stability and balance
- Recommended levels: it really depends on the varietal, but roughly, pH for most whites should be in the range 3.1 to 3.4; most reds 3.3 to 3.8; TA levels should be in the range 5 to 8 g/L as tartaric.

3. Dissolved Oxygen (DO)

- Frequency: As needed, especially after handling like re-racking. You may want to check your DO if you see your wine frequently requiring high amounts of SO_2
- Purpose: Track oxygen exposure and risk of oxidation
- Recommended levels: less than 0.4 g/L or 5% DO relative to saturation

4. Volatile Acidity (VA)

- Frequency: Monthly
- Purpose: Detect spoilage from acetic acid bacteria
- Recommended levels: <0.6 g/L as acetic acid; legal limit in most places is <1.2 g/L
- Sentia analyzer is a good tool that includes VA on its menu of tests.

5. Microbial Analysis

- Includes: Brettanomyces, lactic acid bacteria, acetic acid bacteria
- Frequency: Periodic or if faults suspected
- Recommended levels: varies depending on test performed

6. Sensory Evaluation

- Frequency: Regular (every few weeks). This is the fun part of the winemaking process! We encourage you to taste-test your aging wine frequently. Your palate can also help you decide if you need to make any adjustments.
- Purpose: Identify early signs of faults or imbalances

Common Issues During Oak Aging (and How to Fix Them)

1. Oxidation

Symptoms:

- Browning color
- Nutty, sherry-like aromas
- Flattened fruit character

Causes:

- Excess oxygen exposure; Low SO_2

- Poor topping practices

Solutions:

- Adjust free SO_2 immediately, and maintain regularly
- Minimize oxygen exposure during handling
- Blend with fresher wine if appropriate
- In severe cases, consider fining or repurposing

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2. Volatile Acidity (VA) Increase

Symptoms:

- Vinegar or nail polish aromas
- Elevated acetic acid

Causes:

- Acetic acid bacteria
- Oxygen exposure; low SO_2

Solutions:

- Reduce oxygen exposure
- Maintain adequate SO_2
- Sterile filtration if necessary
- Blend down if within acceptable limits

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3. Brettanomyces Contamination

Symptoms:

- Barnyard, smoky, medicinal, or “funky” aromas

Causes:

- Contaminated barrels
- Poor sanitation

Solutions:

- Confirm with lab testing
- Add SO_2 to inhibitory levels
- Consider filtration
- Retire heavily contaminated barrels

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4. Reductive (Sulfur) Faults

Symptoms:

- Rotten egg (H_2S), burnt rubber, or onion aromas

Causes:

- Low oxygen conditions
- Nutrient deficiencies

Solutions:

- Rack and aerate
- Copper fining (with caution and bench trials)
- Ensure proper nutrient management (especially YAN levels) early in fermentation

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5. Excessive Oak Extraction

Symptoms:

- Overpowering vanilla, toast, or woody flavors
- Harsh tannins

Causes:

- Too much time in new oak
- High surface-area-to-volume ratio

Solutions:

- Transfer to neutral barrels or tank

- Blend with less-oaked wine
- Extend aging to allow integration

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6. Microbial Spoilage

Symptoms:

- Cloudiness, off-aromas, unexpected refermentation

Causes:

- Lactic acid bacteria, yeast contamination

Solutions:

- Maintain SO_2 levels
- Use sterile filtration before bottling
- Sanitize equipment and barrels thoroughly

Best Practices for Successful Bulk Aging

- **Maintain a strict topping schedule**
- **Keep and maintain a detailed lab notebook. Track all analytical data consistently**
- **Keep detailed barrel records**
- **Use sensory evaluation alongside lab testing**
- **Practice rigorous sanitation protocols**
- **Perform bench trials before major corrections**
- **Clean and sanitize barrels each season using steam, percarbonates, ozone, or other agents suitable for wine barrels. Store unused barrels with solutions of citric acid/sulfite mixtures to preserve.**

Final Thoughts

Bulk aging in oak barrels is both an art and a science. While oak can elevate a wine's complexity and structure, it also introduces risks that must be actively managed. A disciplined approach—

combining regular testing, environmental control, and thoughtful intervention—ensures that your wine develops as intended and reaches its full potential at bottling.

By staying proactive and responsive throughout the aging process, winemakers can turn potential problems into opportunities for refinement and excellence.