Wines

Revised 2024

Heat Exposure

Storage Time	Temperature
Never	86°F or above (30°C)
Spikes of 30 minutes or less	85°F or below (29°C)
1 to 4 weeks	75°F or below (24°C)
Long-term storage	50 to 60°F (10 to 16°C)

Cold Exposure

Storage Time	Temperature
Never	23°F or below (-5°C)
Spikes of 30 minutes or less	32°F or below (0°C)
1 to 4 weeks	50°F or below (10°C)
Long-term storage	50 to 60°F (10 to 16°C)

Bottled and bulk wines change with time in ways that are greatly influenced by storage temperatures. Traditionally, wine is stored at (underground) cellar temperatures between 50 and 60°F (10 to16°C) and our empirical expectations of a properly aged wine are based on this temperature range. The hundreds of concurrent aging reactions that contribute to the aroma, flavor, structure, color and healthiness of a wine all precede at individual rates. They are exponentially and differently accelerated by elevated temperatures.

Because of these multiple and unpredictable changes in the aging of the wine, temperatures higher than the ideal long-term storage range shown above are generally considered undesirable. While most commercial wines are stabilized against aesthetically objectionable instabilities such as protein hazes or crystal precipitates, there are no rapid or standardized tests to assure the sensory quality of a wine

without actually tasting it. However, the subjective aroma and flavor qualities of a wine is the most important criteria that determine the value of the product that can range across multiple magnitudes ($2 to $5,000 per bottle). Some winemaking techniques, referred to as thermovinification such as *flash détente*, involve deliberate short time/high temperature heating of must to ca. 180°F (82°C) followed by rapid cooling via vacuum expansion prior to fermentation, to achieve desirable aging effects before the grape juice is turned into wine. While this technique may incur objectionable aroma characteristics such as noticeable amounts of isoamyl acetate, they remain popular as they allow red wines to be released to market earlier.

Both the high and the low temperature tolerances of a given wine depend on its original chemical composition, stabilization treatments at the winery, as well as its provenance and previous storage history. On the positive side, wines stored at these historical temperatures can age and improve with the development of "bottle bouquet" and the "softening" of harsh characters for a more supple "mouthfeel". This ability to develop and become more complex in the bottle has elevated wine from a mere beverage to a glorious and precious experience.

Excessive Hot Temperatures

The greatest storage hazards for wine are associated with elevated temperatures as well as with temperature fluctuations. Any elevated temperatures, above 60°F (16°C), accelerate the maturation process, may change their varietal character or their sense of origin, and can shorten the life expectancy of a wine, especially white wine. Temperatures above 75°F (24°C) greatly and untypically age most wines, leading to undesirable aroma, flavor and color changes. Diurnal temperature spikes during the commercial shipping of wine are not unusual but should be unquestionably avoided. Within the entire distribution chain from winery to wine consumer, wines should be maintained at consistent temperatures and never see even short-term exposure to temperatures of 86°F (30°C) or above.

Note that as bottles are exposed to external sources of heat, a temperature gradient will slowly form between the wine in contact with the glass, and the wine at the core of the bottle. Thus, each volume of wine inside a bottle, or any container, will be subjected to heat depending on its location from the source and depending on any mixing or convection phenomena as the wine is moved. In general, one should ensure that wine be transported and stored refrigerated and in an equally cautious and detectable fashion as ice cream, fresh produce, or pasteurized milk.

Impact from high temperatures may include the following.

1. Visible protein hazes are occasionally precipitated by elevated temperatures in marginally heat-stabilized wines. These hazes constitute only an aesthetical flaw, but over-stabilizing a wine against their appearance can hide damage to its sensory qualities.
2. Temperatures above 60°F (16°C) may stimulate the growth of dormant microbes, leading to off-aromas and-flavors, hazes, and/or pressurization due to the evolution of carbon dioxide (CO_2).

3. Temperature fluctuations test the integrity and position of the bottle closure, especially corks, and can lead to seepage, leakage, and possible introduction of air to wine, with subsequent spoilage of aroma and flavor constituents.
4. Leakage and seepage of wine past the closure caused by excessive temperatures and resulting headspace pressure will damage the label and other packaging materials and may make the wine un-saleable.
5. Storage at elevated temperature may cause excessive extraction of (off-) odors from the bottle closures as well as increased scavenging and loss of protective sulfur dioxide or certain wine aromas.
6. Early experience with shipping barrels of wine in excessive heat produced accelerated oxidation. A significant browning of white wines, with aldehydic aromas of Spanish Sherry, caramel and nuttiness, was given the name “Madeirization”. This is usually a grave defect unless the wine was intended to be an oxidized style (e.g., Madeira, Sherry, Port) in the first place.
7. Most wines naturally contain traces of a precursor to a probable human carcinogen, ethyl carbamate, that can form at accelerated rates at elevated temperatures, especially above 86°F (30°C).
8. High temperatures also test the integrity of sparkling wine bottles by causing the already high pressures (≈90 psi (6,000 hPa)) to rise dramatically. Consequently, loss of sparkling wine by bottle bursting is reported as a result of high temperature exposure.

Excessive Cold Temperatures

Impact from excessively cold temperatures may include the following.

1. Wines stored at cooler than recommended temperatures below 50°F (10°C) may not develop their full potential for aroma by nose and flavor by mouth.
2. Storage at extremely temperatures of 32°F (0°C) and below, even for as little as 1 hour, can cause the natural precipitation of potassium bitartrate in the form of visible crystals in white wines and in the form of colored crystals or a sludge-like mixture of crystals in red wines. This material is not re-soluble in the wine. While its presence is considered only a visual defect, it can be confused by consumers with broken glass which may create litigation issues.
3. At temperatures below 23°F (-5°C) wines with an alcohol content of 14% by volume and below will start to freeze, causing corks to push out and eventually, bottles to break.
4. Moving bottles from very cold storage to a warmer environment will cause condensation of water on the bottle, labels, and cork depending on the relative humidity of the surrounding air. This can easily lead to mold growth and significant damage to the entire package.

Storage Positions

1. Ideally, all wines are stored in refrigerated warehouses and shipped in refrigerated containers/trucks with the temperature exposure continuously logged to assure that the refrigeration system has indeed been working.
2. Wine bottles closed with corks, including bark and synthetic, should be stored upside down or sideways to minimize the gas exchange between the outside atmosphere and the wine inside to avoid accelerated oxidation. Individual cases of wine should be marked to indicate which position the bottles are in.
3. Ideally, refrigerated transportation should be used to maintain constant and optimal temperature conditions for the wine.
4. In very hot climates, including shipments across the equator or through the Panama Canal, the ability of refrigerated containers to maintain a steady cool temperature may be compromised.
5. In general, it is recommended to avoid shipping wine unrefrigerated during the hottest months or without temperature management (protection from freezing) during the coldest winter months of the year.
6. When wine is stored or moved in containers on truck, railroad cars, or container ships, especially in or through hot climates, one needs to be aware that wine stored in the upper part of the container exposed to direct sunlight, or along the sidewalls of the container will heat up the fastest.
7. Furthermore, if wine is shipped in containers or bulk tankers which are unrefrigerated, the duration of transportation should be minimized to mitigate deterioration of the product.
8. If wine is sold online and distributed direct-to-consumer (DTC) via common carriers, it should be assured that the wines do not sit in unrefrigerated delivery trucks or on loading docks for extended periods of time, and that delivered boxes of wine are not placed on sun-exposed driveways and porches.
9. If refrigerated trucks are not available, it is preferable to use non-isolated containers in order to avoid the accumulation of hot air in the container space above the pallets of wine during the day and continuous heat dissipation during the night. Instead, the pallets inside the container should be covered with insulation blankets or similar materials.
10. Bulk wine trucked in partially filled tankers tends to slosh significantly, increasing the loss of sulfur dioxide and the risk of oxidation if the head space in the tank in not sparged with inert gases such as nitrogen or argon.

Length of Storage:

If storage is provided without excessive ultra-violet (UV) light exposure, and the temperatures remain constant (within ± 2 to 3°F or ± 1 to 1.5°C of the appropriate storage temperature) and in the ranges listed, typical white table wines should retain their quality for about three years after bottling. Red table wines, depending on winemaking style, may retain or improve their quality for three to ten years. Note that these are very general guidelines, as some wines are made to be consumed within their first year while others may age gracefully for several decades. However, experience and research have shown that improper

storage conditions, during distribution through the entire supply chain, from producer to négociant to shipper to importer to distributor to retailer or restaurant to consumer, is the most common cause of loss of a wine's quality and value. Documentation of both authenticity and provenance, temperature monitoring of shipments and storage conditions, and the traceability of wines during their entire lifespan is crucial to prevent such losses.

GCCF is indebted to Dr. Christian E. Butzke, Professor of Enology and Senior University Fellow for Innovation & Entrepreneurship, Purdue University, West Lafayette, Indiana, for the review and revision of this topic. Additional contributions to this GCCF guidance document were provided by PEB Commodities, Inc. from Ms. Stephanie Brecht, Principle Consultant, who has a BS in Fermentation Science (Viticulture & Enology, UC Davis) and years of experience in the food, beverage and pharmaceutical industries, and Dr. Patrick E. Brecht, President, who has a PhD in Postharvest Technology (UC Davis) and extensive experience in transportation and storage of special commodities.