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Commercial Winemaking Production Series

Wine Storage Guidelines

Wines stored at the appropriate temperatures can age and improve

By Christian Butzke

Enology Professor

Department of Food Science
Purdue University

butzke@purdue.edu

Once your precious wine leaves the sheltered winery, it is crucial to know what temperatures it can be exposed to during shipments and storage and still retain its quality.

Wine shipment covered with an insulating blanket

Empirical wisdom has taught us that bottled and bulk wines change with time in ways that are greatly influenced by storage temperatures. Traditionally, wine is stored at cellar temperatures between 10 and 16°C (50 to 60°F), 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 proceed 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 in Table 1 on page 3 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.

Aging reactions

Aging reactions in wine have substantially different rates, which explains why “speed-aging” just by elevated temperature alone will not yield a wine comparable to one that was aged at a traditional cellar temperature of around 13°C (55°F). Some examples of temperature increases that would double the aging reaction rate are 3.8°C for oxygen uptake, 7.8°C for browning, 16°C for ethyl carbamate formation, and 30°C for sulfur dioxide decline in white wines.

The aroma (by nose) and flavor (by mouth) qualities of a wine are the most important criteria that determine the value of the product, which can range from $2 to $5,000 per bottle. Both the high and the low temperature tolerances of a given wine depend on its original

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chemical composition, stabilization treatments at the winery, as well as its provenance and previous storage history. On the positive side, wines stored at the appropriate temperatures can age and improve with the development of "bottle bouquet" and the "softening" (mostly precipitation) of harsh tannins for a more supple "mouthfeel." Wine's ability to develop and become more complex in the bottle has elevated it from a mere beverage to a glorious and precious experience.

The greatest storage hazards for wine are associated with elevated temperatures and temperature fluctuations. Any temperature above 16°C (60°F) accelerates the maturation process, may change the wine's varietal character or its sense of origin ("terroir"), and can shorten the life expectancy of a wine (especially of whites). Temperatures above 24°C (75°F) greatly and untypically age most wines, leading to undesirable aroma, flavor, and color changes. Diurnal (day vs. night) temperature spikes during the commercial shipping of wine are not unusual but should be avoided. Within the entire distribution chain from winery to wine consumer, wines should never see an even short-term exposure to temperatures of 30°C (86°F) or above. It can be argued that wine should be shipped and stored under conditions that are at least equal to much less precious commodities such as milk, ice cream, or produce.

Bottle storage conditions

What's too hot?

- Visible protein hazes are occasionally precipitated by elevated temperatures in marginally heat-stabilized wines. These hazes constitute only an aesthetic flaw. However, stabilizing a wine against visual flaws due to heat exposure may hide damages that such exposure caused to its aroma qualities. Sensory damages may only become apparent once the bottle has been opened and tasted.
- Temperatures above 16°C (60°F) may stimulate the growth of dormant microbes, leading to off-flavors, hazes, and excess carbon dioxide.
- Temperature fluctuations test the integrity and position of the bottle closure, especially corks, and can lead to the introduction of air into wine, with rapid spoilage following.
- 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 unsalable.
- Storage at elevated temperature may cause excessive extraction of odors from the bottle closures as well as increased scavenging and permeation-based loss of protective sulfur dioxide or certain wine aromas.
- 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.
- Most wines naturally contain traces of a precursor to a probable human carcinogen, ethyl carbamate, which can form at accelerated rates under elevated temperatures, especially above 30°C (86°F).
- High temperatures also test the integrity of sparkling wine bottles by causing the already high pressures (6 atm = 90 psi) to rise dramatically. Loss of sparkling wine by bottle bursting has been reported as a result of high temperature exposure.

What's too cold?

- Wines stored at cooler than recommended temperatures — below 10°C (50°F) — may not develop their full potential for aroma and flavor.
- Storage at extremely low temperatures — 0°C (32°F) and below — 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 resoluble in the wine. While its presence is considered only a visual defect, consumers may confuse it with broken glass, which may create litigation issues.
- At temperatures below -5°C (23°F) wines with an alcohol content of 14 percent by volume and below will start to freeze, causing corks to push out and bottles to eventually break.

- 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.

What's the preferred bottle position?

- Wine bottles closed with corks (both bark or 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.
- 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.
- In very hot climates, including, e.g., shipments across the equator or through the Panama Canal, the ability of refrigerated containers to maintain a steady cool temperature may be compromised.
- In general, it is recommended to avoid shipping wine unrefrigerated during the hottest months of the year.
- When wine is stored or moved in containers on trucks, railroad cars, or container ships, especially in or through hot climates, the wine stored in the upper part of the container exposed to direct sunlight will heat up the fastest.
- 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.
- Bulk wine trucked in practically empty 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.

Wine ageability

If storage is provided without excessive ultraviolet light exposure, and the temperature is constant (± 1-1.5°C or ± 2-3°F) 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 10 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.

Table 1: Recommended global wine shipping and storage conditions.

Heat Exposure	
Storage Time	***Temperature***
Never	30°C (86°F) or above
Spikes of 30 min or less	29°C (85°F) or below
1-4 weeks	24°C (75°F) or below
Long-term storage	10 to 16°C (50 to 60°F)
Cold Exposure	
Storage Time	***Temperature***
Never	-5°C (23°F) or below
Spikes of 30 min or less	0°C (32°F) or below
1-4 weeks	10°C (50°F) or below
Long-term storage	10 to 16°C (50 to 60°F)

Source: www.foodsci.purdue.edu/research/labs/enology/Wines2008.pdf

Direct shipping issues

Direct, Internet-generated shipments of wine are a popular way to make winegrowing both sustainable for the winery and regional wines more accessible and affordable to the consumer. However, the major global package shipping companies do not have

logistical systems in place that protect wine adequately from damage during shipment and intermediate storage. Obviously especially in the summertime, the nonrefrigerated local delivery trucks are loaded in the early hours of the morning and distribute packages until the late afternoon. Within this 13-hour time window, wines are frequently exposed to temperatures above 26°C (79°F).

Unfortunately, many commercial wines are so over-stabilized that adverse transport conditions that affect the sensory properties and quality of the wine go unnoticed because the wine stays visually intact. No precipitation and haze of heat-instable protein can be observed because the wine was probably treated with a substantial amount of bentonite, which by itself has the capacity to strip a wine of aroma compounds.

Global tracking of individual cases or bottles of wine using GPS and RFID technology have become readily available and are used to protect many of the world's most precious wines.

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www.eprovenance.com — Web site of a company that applies advanced technology to monitor the temperature of fine wines from producer to consumer

Reviewed by:

Richard Linton
Professor of Food Science and
Director of the Center for Food Safety Engineering
Department of Food Science, Purdue University

Bruce Bordelon
Viticulture Professor
Department of Horticulture & Landscape Architecture, Purdue University

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