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Professor Gerbi’s Research Reveals How Oxygen Stabilizes Red Wine Color

Study shows modern winemaking techniques double pigment retention, enhancing both the vibrancy and longevity of red wines.

Thursday, April 9, 2026



Recent research led by Professor Vincenzo Gerbi from the University of Turin has shed new light on the biochemical mechanisms that stabilize color in red wines. The study focuses on how anthocyanins, acetaldehyde, and micro-oxygenation interact to improve the longevity and intensity of wine color, a key factor in both quality and consumer appeal.

Anthocyanins are natural pigments responsible for the red and purple hues in wine. During winemaking, these compounds are prone to degradation, which can lead to a loss of color over time. Professor Gerbi explains that the stabilization process involves the formation of addition dimers—molecular structures where anthocyanins bond together, often with the help of acetaldehyde. This reaction interrupts the polymerization chain, resulting in stable color compounds that no longer have reactive sites for further bonding. One notable product is a mauve-colored dimer with a maximum absorption at 540 nanometers, which contributes to the vibrant appearance of aged red wines.

The research highlights that reducing the amount of free anthocyanins as quickly and efficiently as possible is crucial for achieving favorable color intensity and longevity. This reduction is primarily accomplished through aging in wooden barrels and controlled micro-oxygenation. Both methods introduce oxygen into the wine, which facilitates chemical reactions that bind anthocyanins into more stable forms.

Historical comparisons provide context for these findings. In classic Italian varieties such as Nebbiolo from Piedmont and Sangiovese from Tuscany, wines produced in the last century typically exhibited orange hues after several years of aging—a sign of pigment loss and oxidation. Today, thanks to improved vineyard management and winemaking techniques, these same varieties retain deeper red tones even after three years of maturation. The shift is attributed not only to better oxygen management but also to advances in agronomy, such as improved pruning systems, canopy management, and selection of grape material with higher anthocyanin content.

Quantitative data underscores this progress. Traditionally, grapes containing about 500 mg/kg of anthocyanins would yield wines with only 50-60 mg/L remaining after production—a loss of nearly 90%. Modern practices have doubled pigment retention, with current wines showing 100-120 mg/L of anthocyanins. This improvement is significant for both visual appeal and perceived quality.

The introduction of oxygen into wine does not rely solely on barrel aging or micro-oxygenation devices. Everyday cellar operations—including pumping over, racking, blending, filtration, centrifugation, temperature changes, and bottling—also contribute

to oxygen enrichment. A study by Ferrarini in 2001 measured oxygen uptake during these processes, confirming their role in facilitating beneficial chemical reactions.

Professor Gerbi’s analysis distinguishes between condensation reactions that occur with or without oxygen intervention. While some polymerization can happen naturally in stainless steel tanks without added oxygen, micro-oxygenation leads to a higher proportion of stabilized anthocyanins and non-reactive pigments. This results in wines with more intense and persistent color.

Micro-oxygenation itself involves introducing small amounts of oxygen into wine stored in concrete or steel tanks under controlled conditions. This technique has become a standard tool for winemakers seeking to enhance color stability without relying exclusively on traditional barrel aging.

The findings from Professor Gerbi’s work demonstrate that modern enology combines scientific understanding with technological innovation to produce red wines with greater color stability and longevity than ever before. By managing oxygen exposure at various stages—from vineyard to bottle—winemakers can transform unstable pigments into robust polymers that define the visual character of contemporary red wines.