ask the AWRI

Gases – we have you covered

Carbon dioxide (CO_2) was in short supply to several sectors during early 2023 and was selling at around double the usual price. This cost increase and concerns about sustainability led some winemakers to ask the AWRI helpdesk for advice on how to use CO_2 or other gases most efficiently when protecting wine during storage. In this column, AWRI Oenologist **Ben Cordingley** covers questions about using different gases and which delivery methods provide the most efficient and effective protection.

Why is it important to protect wine from air/oxygen in tanks during wine storage?

Wine is best stored in completely full tanks, with the wine preferably entering the lower portion of the neck at the top of the tank. This minimises the volume of air/oxygen within the small amount of headspace and ensures the lowest amount of wine surface area exposed to air. Thermal expansion and contraction requirements, limits on the number of suitable-sized tanks, and requirements to keep wine batches separate often mean that it is difficult to avoid storing some wines in tanks that are not completely full. Managing the headspace (often called the ullage volume) by keeping oxygen levels above the surface of the wine below 1% helps limits oxidation and the growth of film-forming aerobic microorganisms. Exposure of wine to oxygen can lead to the consumption of sulfur dioxide (SO_2), loss of fruit characters, development of oxidised characters and an increased risk of microbial spoilage.

What gases are used to protect the headspace?

Carbon dioxide, nitrogen, combinations of CO_2 and nitrogen, and argon (an inert or non-chemically reactive gas) are the main gases or gas combinations added to the headspace of tanks during wine storage. Gas can be added from a bulk liquefied cylinder supply, portable gas bottles, or potentially recirculated from gas produced elsewhere in winery operations. Carbon dioxide can also be added as solid dry ice made from liquefied CO_2. Nitrogen is often generated onsite at larger wineries.

Does it matter how gas is added?

The manner in which gas is added to tanks makes a large difference in the volume of gas required and its effectiveness. Adding gases lowers the ullage oxygen concentration by either displacement of the oxygen at the wine interface or by dilution, where the oxygen concentration is lowered by mixing with the added gas. Displacement occurs when a gas that is heavier than air (such as CO_2 or argon) is added close to the surface of the wine. Slow delivery with laminar flow of the delivered gas results in limited mixing and allows the heavier gas to layer above the wine, pushing the air above the wine upwards. Laminar flow can be achieved through lower flow rates, larger diameter tubing, or with the use of floating gas diffusers to lower flow velocity. Faster flow rates that give turbulent flow result in mixing and no formation of a layer of gas. Addition of dry ice to the wine surface results in the slow sublimation of solid CO_2 directly to the gaseous form, creating a blanket of CO_2 gas at the wine interface. When nitrogen is used in the headspace of a tank it mixes with air, lowering the oxygen concentration of the entire headspace, but this requires much greater volumes of gas.

What are the main differences between using CO_2, nitrogen and argon?

The solubilities of CO_2, nitrogen and argon in wine in are 1.72, 0.02, and 0.05 vol/vol respectively. Their relative densities to air are 1.53, 0.97 and 1.38 respectively (Allen 2009). The greater relative density of CO_2 and argon make them effective blanketing gases, although the much higher solubility of CO_2 means that the duration of protection is shorter as it rapidly dissolves into wine. Nitrogen mixes with air because of its similar density. Extensive use of CO_2 as a blanketing gas can increase dissolved CO_2 levels in wine above recommended levels for the wine style. Mixtures of nitrogen and CO_2 typically used in fixed line delivery systems in ratios of 70/30 or 80/20 can help control dissolved CO_2 levels, while maintaining adequate protection at lower costs. The properties of gas mixtures are proportional to that of the constituents.

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How much gas is needed?

Del Barrio-Galan *et al.* (2023) and Girardon et al. (2019) suggest that displacement techniques that form a protective blanket of a gas that is heavier than air (CO_2 or argon) require a minimum addition of between 0.25 and 0.50 headspace volumes of gas. If dry ice is used, labour costs can be considerable, due to the need for regular additions. Far fewer argon additions are required due to its low solubility in wine. Much larger volumes of gas are required if diluting the oxygen concentration in the tank rather than displacing it. Allen (2009) suggests the amount required to lower headspace oxygen to below 1% using nitrogen could be as high as five headspace gas volumes, or ten times greater gas volumes than required for displacement.

Larger wineries commonly have fixed line gas delivery systems servicing each tank, often at flow rates up to 10 L/min. Gas flow rates vary depending on which gas or mixture is being used and can be altered for different headspace volumes. These systems can be either operated continuously or programmed to deliver gas at fixed intervals. Future automation using sensors to measure gas levels will likely make it possible to deliver gas to a headspace precisely when required.

What is the most cost-effective option for protecting the headspace of stored wine?

Prices of each gas type are subject to change and typically depend on how much is purchased. Some gases are delivered in bulk, while others are supplied in cylinders that can be subject to rental fees. Fixed line delivery systems using floating gas diffusers are likely to provide the best protection but require capital investment for their installation. Carbon dioxide lost during dry ice generation and increased labour costs associated with frequent reapplication may make dry ice uneconomical, particularly as CO_2 prices increase. While the current price of argon is still higher than for CO_2, the need for fewer reapplications makes it a viable alternative worth exploring. Use of green energy for the future production and transport of argon may also contribute to decarbonisation and increased sustainability of the wine industry.

References

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AWRI helpdesk

The AWRI helpdesk provides a free-of-charge technical advice service to Australia's grapegrowers and winemakers. For further information about gas coverage or any other technical matter, contact the helpdesk on (08) 8313 6600 or helpdesk@awri.com.au

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