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Understanding the Complex Evolution of Wine Aromas

Luigi Moio's lecture explores the intricate interplay of chemical compounds in wine, from grape variety to aging processes.

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Luigi Moio, from the University of Naples, recently delivered a lecture on the intricate nature of wine aromas and their evolution over time. The aroma of wine is a complex interplay of chemical compounds derived from grapes, fermentation, and aging. Understanding the layering of these aromas and their development is crucial for winemakers.

Primary aromas in wine come directly from the grapes and are closely tied to the grape variety. Not all grapes have immediately noticeable aromatic compounds. For instance, Trebbiano lacks significant aromatic precursors, unlike Muscat, which is rich in terpenes responsible for its floral notes. In neutral musts, the predominant smell is herbaceous, due to the enzymatic breakdown of linoleic and linolenic acids. This reaction forms six-carbon alcohols and aldehydes, which are responsible for typical vegetal notes. Additionally, in varieties like Sauvignon Blanc or Cabernet Sauvignon, the must contains compounds such as pyrazines, which enhance the herbaceous character.

During alcoholic fermentation, yeasts convert sugars into ethyl alcohol and carbon dioxide. Alongside these main products, acids such as acetic, butanoic, hexanoic, and octanoic are also generated. In high concentrations, these can impart unpleasant notes like cheese or barnyard. Higher alcohols, such as 3-methylbutanol, 2-methylbutanol, and 2-phenylethanol, develop simultaneously, contributing varying sensory characteristics. Notably, 2-phenylethanol adds subtle rose floral notes, while other higher alcohols can resemble solvents or varnishes. Esters form through reactions between alcohols and acids during fermentation, responsible for fruity and fresh notes in young wines. Significant esters include isoamyl acetate (banana), ethyl butanoate (pineapple), and ethyl octanoate (tropical fruits). The balance between esters and higher alcohols determines the wine's aromatic profile. If esters dominate, the wine has a fruity and pleasant character; if higher alcohols prevail, the profile tends to be more generic and vinous.

The aroma of wine can be described as a layering of volatile components that combine and transform over time. Five main layers can be identified: aldehydes and six-carbon alcohols responsible for initial herbaceous notes; ethyl alcohol and fatty acids forming the common olfactory base of all wines; higher alcohols adding complexity but perceived as defects if excessive; esters providing freshness and fruity notes in young

wines; and specific varietal compounds like terpenes, thiols, methoxypyrazines, and rotundone, which give the wine its varietal identity.

An interesting aspect is the "fermentative aromatic base," a set of molecules common to all wines, including alcohols, organic acids, esters, and acetaldehyde. This base acts as an "aromatic buffer," absorbing most sensory changes and allowing only some compounds to emerge. Molecules like isoamyl acetate and beta-damascenone can modify this base, adding distinctive characters to the wine's olfactory profile.

The complex aromatic structure of wine can be compared to an olfactory orchestra. Some varietal wines are distinguished by the presence of a dominant molecule, a true "soloist" guiding the aromatic perception. This is the case, for example, with Sauvignon Blanc, where volatile thiols play a key role in defining the bouquet. On the other hand, there are "orchestral" wines, without a single dominant molecule, where the olfactory perception results from the balance between multiple aromatic components. In these cases, environmental variability and terroir influence the wine's identity more significantly, making it more sensitive to external factors.

Wine aging is a dynamic process where chemical balances between volatile molecules undergo continuous transformations. Fruity esters, initially predominant in young wines, tend to hydrolyze over time, releasing alcohols and acids that can negatively affect the aromatic perception. This transition phase can cause a temporary decrease in olfactory intensity, a sort of "dormant phase" where the wine seems neutral from an aromatic standpoint. Later, if the wine has enough aromatic precursors, these can release new odoriferous molecules, restoring complexity and richness to the bouquet.

Oxygen plays a crucial role in the transformation of wine aromas. Its impact varies depending on the type of wine. In white wines, oxygen poses a significant threat, promoting the formation of compounds like acetaldehyde and phenylacetaldehyde, responsible for unpleasant oxidative notes like cooked apple or caramel. In red wines, however, the presence of anthocyanins and tannins provides natural antioxidant protection, slowing down degradative processes. Controlling oxygen during winemaking and storage is therefore essential to preserve the wine's aromatic quality over time.

Another determining factor in the evolution of wine aroma is storage temperature. Scientific studies have shown that high temperatures accelerate the degradation of volatile esters, reducing the wine's aromatic freshness. For example, isoamyl acetate, responsible for banana notes in young wines, hydrolyzes quickly at temperatures above 20°C. In contrast, ethyl esters, more resistant, can contribute to greater aromatic longevity, making them especially desirable for producing wines intended for aging.

Aging in wood adds another layer of complexity to the evolution of wine aroma. Oak barrels impart phenolic compounds like vanillin and whisky-lactone, which interact with the pre-existing aromatic profile. In wines with low aromatic potential, these compounds can dominate varietal characteristics, leading to an excessive presence of wood notes. Conversely, in wines with high aromatic potential, the presence of precursors allows for a harmonious fusion between varietal aromas and compounds imparted by the barrel, ensuring greater balance and complexity.

The aroma of wine results from a complex balance between volatile molecules that evolve during winemaking and aging. Understanding these processes allows professionals to intervene in fermentation and cellar techniques to achieve desired aromatic profiles.