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Italian researchers create first global metabolomic atlas of grapevines

Built from 126 varieties, the atlas lets growers compare grapes by chemistry, revealing unexpected similarities beyond genetics.

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Researchers at Italy’s Fondazione Edmund Mach have developed what they describe as the first global metabolomic atlas of grapevine varieties, a new reference tool that could help growers and winemakers compare grapes by their chemical composition

rather than relying only on genetic data.

The work, published in the Journal of Agricultural and Food Chemistry, is based on the analysis of 126 grape varieties from different parts of the world. The researchers say the atlas offers a way to identify similarities and differences in the metabolic makeup of grapes, opening new possibilities for varietal selection, research on wine potential, and the study of alternatives to traditional grapes.

In practical terms, the atlas focuses on the compounds that grapes bring into the winery. Those include sugars, acids, polyphenols, aromatic compounds, and aroma precursors, all of which influence how a wine will taste, smell, and develop. Until now, relationships among grape varieties have been studied mainly through genetics. The researchers said DNA analysis remains essential, but it does not fully describe the chemical profile of a grape or the material that directly affects wine production.

The project, called Grape Metabolome, was designed to fill that gap by building a large-scale map of grape chemistry. By comparing the metabolic profiles of varieties, the researchers said they were able to complement genetic information and draw a closer connection between genotype, or inherited traits, and phenotype, or the observable chemical expression of the grape.

The findings suggest that each grape variety carries a distinct metabolomic fingerprint. That signature, the researchers said, is defined enough to make it possible to group varieties according to their chemical composition. One of the main results is that some grapes with clear genetic or physical differences can still show close chemical similarities.

Among the examples highlighted in the study are Teroldego, Lagrein, and Marzemino, which showed related metabolomic profiles. The researchers also found similarities between Cabernet Franc and Merlot, between Vermentino and Xarello, and between Manzoni and Riesling. The value of those comparisons, according to the research team, is that they may help identify varieties that could offer comparable raw material for winemaking even if they do not share the same genetic background or vineyard appearance.

That possibility is especially relevant for growers and producers looking at alternative grape varieties while trying to preserve the identity of a wine style. The researchers were careful to frame this as a potential application rather than a finished decision-making tool. Similarity in chemical profile does not automatically mean identical results in the cellar, where climate, site, ripeness, farming practices, and winemaking methods also shape the final product.

Even so, the atlas could give winemakers a new way to assess a grape's aromatic and phenolic potential before fermentation begins. By examining metabolites and their precursors, researchers and producers may be able to build a more detailed picture of what a variety can contribute in terms of structure, aroma, and style.

One of the study's more notable observations involved aromatic grapes. Varieties such as Muscat, Malvasia, and Gewürztraminer formed a clearly recognizable metabolomic group, regardless of berry color. That means aromatic grapes with white, pink, or red berries can still show close chemical relationships because of the compounds tied to aroma and aroma precursors.

The researchers said this finding underlines an important point: the biochemical identity of a grape is not determined only by berry color. Instead, it depends on a broader set of compounds that together define its enological potential. For scientists and producers, that could offer a more nuanced way to classify grapes and to understand why some varieties behave similarly in winemaking while others do not.

To make the results easier to use, the team has also launched an interactive platform called Grape Metabolome Explorer. The tool allows users to visualize relationships among grape varieties through interactive maps that show how they are distributed according to their metabolic profiles. Users can explore clusters, compare varieties, and examine chemical affinities across the dataset.

Fondazione Edmund Mach said the platform is intended to serve both research and industry. For winemakers, it offers a new way to investigate grape diversity and to examine possible links between lesser-known grapes and established varieties. For researchers, it provides a data-based starting point for further study of grape composition and its role in wine quality.

Panagiotis Arapitsas, who leads the Metabolomics Unit at the foundation’s Research and Innovation Center, said in the project materials that every variety brings a specific chemical heritage into the winery, and that this chemical makeup forms the raw material from which wine is made. He said the new atlas helps explain why some varieties share traits while others differ in important chemical ways.

The foundation said it plans to make the atlas available to wine professionals as a resource for understanding the characteristics and potential of different grape varieties. The project marks a move toward a broader characterization of grapes, in which genetic data is paired with direct analysis of the compounds that can influence the composition and final characteristics of wine.

The study appears in the Journal of Agricultural and Food Chemistry under the DOI 10.1021/acs.jafc.6c04648, and the interactive database is available through the Grape Metabolome Explorer developed as part of the same project.