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Peeling away the secrets of color and flavor

Scientists looking for ways to enhance wine's appeal in the glass and on the tongue are untangling the interactions of flighty, fickle pigments and tannins

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The color of red wine, any oenophile could explain, comes from the grape skin.

In the skin, however, the pigments are actually purple-blue and it is only over time that the color evolves to the ruby red of a cabernet sauvignon. Yet, if you leave a dirty wine glass out overnight, the remnants will turn purple. And if you wash your glass, you might notice a blue tinge to the rinse water. Drink enough red wine and your mouth might turn blue.

With red wine color, there is more than meets the eye.

The red color that we see so simply with our eyes has been a source of endless frustration among both winemakers and wine scientists. Andrew Waterhouse, an enologist at University of California at Davis, says for a long time researchers had simply given up studying red wine color because they considered it an "intractable problem."

In 1933, the French chemist Jean Ribereau-Gayon declared that separating pigments from old wines was une impossibilite. Some claim that wine contains so many organic compounds that it rivals the complexity of our blood. It is only in the past decade, says Waterhouse, that scientists have progressed in understanding red wine color and his colleague and former student, James A. Kennedy, has been at the forefront of that research.

Kennedy, an affable man in his early 40s, has paid his dues sweating in the shadeless vineyards of California, Australia and Oregon. He is now an assistant professor at Oregon State University in Corvallis who wants to make red wines look redder and taste better.

On a recent morning, he was standing in his lab in front of a four-tiered contraption that performs a procedure known as reverse-phase high performance liquid chromatography -- a technological boon to the study of wine. Next to the device, a Ziploc bag hangs half open and crayon-size vials filled with a deep purple liquid are tumbling out.

"So you see a red grape, you extract that stuff and make a red wine," Kennedy said. "But that color -- those compounds responsible for the red color -- change very rapidly. Within a year, the compounds that were initially responsible for the red color are gone. . . . I find that fascinating as a chemist."

Anyone who has spilled a glass of red wine on a white tablecloth has performed their own chromatography experiment, as they watch with horror the brown epicenter of the stain radiate out to a thin blue ring. The color pigments separate themselves on the basis of their speed through the fabric. Kennedy's machine does a similar thing: it extracts individual compounds and measures their color properties. This allows Kennedy to understand how wines change over time.

Napoleon reputedly said that "Nothing makes the future look so rosy as to contemplate it through a glass of Chambertin." Napoleon's Chambertin appeared "rosy" because it absorbed every color except for red, Kennedy explains. The color of a young red wine comes from anthocyanins, a category of plant pigments that makes roses red and cornflowers blue. For these pigments, the transition from red to blue can be instantaneous: like that final tug that turns a folded sheet of paper into an origami swan.

All molecules have shapes and anthocyanins, like paper, are typically flat. In an acidic solution like wine, the pigment will be red, while in an alkaline solution -- saliva is one -- it becomes blue. The shift in shape is relatively minor, but the color change can be dramatic. Although this effect may turn our mouths blue, Kennedy says that in wine, these pigments are actually flipping between a red form and a colorless form.

"Maybe 10 to 20 percent are in the colored form and upwards of 70 to 80 percent are in this colorless form," he says. One question winemakers have is how do you lock these things in the colored form? If they can do that, they can make red wines more red, which would please both consumers and wine critics.

Understanding these fickle pigments has been no simple task -- Richard Wilstatter received a Nobel Prize for it in 1915 -- but anthocyanins are just the beginning of the story for red wine color. Frenchman Riberau-Gayon replicated Wilstatter's methods to crystallize pigments from grape skins, but when he tried this approach with wine, it failed. "Seventy years later," Kennedy and his co-authors wrote in their book "Red Wine Color," "the mystery still resonates."

Even though Ribereau-Gayon could not isolate the pigments, his failed attempts showed that the red compounds in wine must change very rapidly. "As wine ages," Kennedy says "it becomes increasingly brick red in color. It's almost like you're taking that red color and you're superimposing on a yellow color so it becomes more brick red overall in appearance." It is the outcome of this aging process, inextricably linked with the changing color, that can produce either a great wine or, as Kennedy describes it, "a green banana."

Red wine flavor is practically defined by its tannins, a group of coiled compounds that Kennedy says give wine a yellowish tint and a bitter bite. Plants have evolved tannins to combat the onslaught of enemies they face every day: caterpillars gnawing on their leaves and monkeys stealing their unripe fruits.

In response, plant-eaters evolved their own defenses against these tannins. Human saliva, for instance, contains proteins that neutralize these tannins before they head to our stomachs, where they can upset digestion.

When we drink wine, these salivary proteins are pulled from our mouths, and we get that puckering sensation known as astringency. Kennedy says, "If you have a big huge red wine that is just too astringent, it's disgusting."

He thinks that when you link these yellow tannins with the red anthocyanins, the salivary proteins can no longer attach. Consequently, the astringency becomes "less grippy" and the flavor is "harmonized with the rest of the wine." At the same time, these unstable red pigments become permanently locked in their colored state.

Kennedy's colleague Jim Harbertson, an enologist at Washington State University in Prosser, is a proponent of this hypothesis but cautions that "no one has proved it."

"Today," says Kennedy, "we have only definitively determined the structure of one anthocyanin built on one tannin molecule. When it gets bigger than that, we are clueless as to what that structure is."

He turns back to his chromatography machine and opens up a sample file, a drop of cabernet transformed into a trace of data. He points at the hump-shaped line on the screen, "We've got two compounds here. The blue trace is catechin, and the red trace is another compound that is the major sub-unit in a tannin molecule. It's called epicatechin."

These molecules -- catechin and epicatechin -- have been made famous as two of red wine's flavonols, which many researchers claim offer health benefits. They are, however, colorless.

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