Electrochemistry captures coffee's taste, powering a more consistent cup

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It takes a surprising amount of work to keep coffee consistent cup to cup. An electrifying new approach from University of Oregon researchers could make the task easier. They've discovered a way to

measure the flavor profile of a cup of coffee—by sending an electrical current through it.

New tool for coffee consistency

The advance could help cafes improve their quality control with a simple measurement. It also pins down something that's long eluded food scientists: how to quantify and separate the factors that influence how something tastes.

"It's an objective way to make a statement about what people like in a cup of coffee," UO chemist Christopher Hendon said. "The reason you have an enjoyable cup of coffee is almost certainly that you have selected a coffee of a particular roast color and extracted it to a desired strength. Until now, we haven't been able to separate those variables. Now we can diagnose what gives rise to that delicious cup."

Hendon's team repurposed a lab tool that's usually used to test batteries and fuel cells. In the new study, they found it could identify a chemical fingerprint of coffee, a way to quantify a flavor profile that a roaster and barista could then aim to replicate.

They published their findings in the journal *Nature Communications*.

Limits of current flavor measurements

Dozens of variables influence a good cup of coffee, including water temperature, grind size, the amount of beans and the beans themselves. Small changes in protocol can lead to big changes in flavor.

Cafes that cater to coffee aficionados invest a lot of effort in consistency. They're constantly adjusting parameters so a regular

customer will find that a shot of their favorite espresso tastes the same today as it did yesterday.

The industry standard to determine the flavor profile is to measure the refractive index of the coffee. (Similar approaches are used in winemaking and other industries.) This measurement of how light bends as it moves through the liquid reflects the strength of the coffee. But strength alone doesn't capture the cup's flavor.

Most of the flavor people detect in a cup of coffee comes from a combination of strength and darkness, which together make up what Hendon calls a coffee's "roastiness."

How the electrochemical method works

People's preferences are very individual, he emphasizes. So this isn't about making a better cup of coffee, but rather a more consistent one that reflects someone's individual tastes.

The tool that Hendon's team adopted, called a potentiostat, is commonly used in the field of electrochemistry. It controls voltage and current and tests the performance of batteries and fuel cells. The device is highly sensitive to the composition of the material that it measures.

By repurposing the tool to examine the electrical response of coffee, in essence, looking at how electricity interacts with the drink, it offers a more nuanced measurement of coffee's flavor profile, Hendon's research found. He and his team, including former doctoral students Robin Bumbaugh and Doran Pennington, identified distinct signatures from different kinds of beans prepared in different ways.

That provides a target for a barista to replicate, one that reflects the flavor of the coffee more than strength alone.

Real-world testing and future promise

As a real-world test of their technique, they sourced four different samples from a roaster in England. The beans seemed identical to the naked eye, and the researchers didn't know which was which. But their electrochemical approach accurately identified the sample in the group that had failed the roaster's quality control.

"In the short term, we hope this is something that will make a difference in coffee shops and in the coffee industry," Hendon said.

And for the coffee nerds at home, he added, "this is the first step towards understanding why you enjoy coffee, at a molecular level of precision."

More information: Robin E. Bumbaugh et al, Direct electrochemical appraisal of black coffee quality using cyclic voltammetry, *Nature Communications* (2026). DOI: 10.1038/s41467-026-71526-5
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