

Crash Course in Coffee Science

Coffee and espresso—what’s the difference?

by DR. JOSEPH JOHN

People over much of the world have been drinking coffee, prepared one way or another, for well over 400 years. Those in Western Europe, especially in Italy, have been consuming early versions of espresso produced with steam machines for nearly 100 years. Modern espresso did not appear on the scene until about 1940, when the spring lever machine was introduced; its commercial success led to the more advanced pump-driven machines that generate water pressure at about 140 pounds per square inch.

All coffee beverages share one common feature: They are consumed simply for enjoyment—there is little or no nutritional value in basic coffee beverages. Some of this pleasure is derived from the warmth it provides, particularly on a cold day. Part of it comes from caffeine’s ability to wake one up in the morning, kick-starting the workday. But most of the enjoyment comes from what one would colloquially refer to as coffee’s unique, pleasant—but nevertheless acquired—taste.

Technically, “taste” usually means “flavor,” consisting of taste as sensed by the tongue and aroma as detected by the nose. In fact, much of this flavor sensation—perhaps as much as 80 percent in the case of coffee—comes from the aroma component.

A CUP OF COFFEE

A cup of coffee is made by bringing about six ounces of nearly boiling water into contact with about nine grams of ground coffee at normal atmospheric pressure. During this process, some portion of the coffee—about 20 percent by weight—ends up in the hot water. Most of these extracted compounds are water-soluble and account for coffee’s aroma, taste and color, and others are not soluble in water and contribute to its body. Unfortunately, much of the aroma vapors, released during the extraction process, simply escape into the room. Brewed coffee lacks a strong mechanism to capture these aroma molecules and hold them in the cup.

Coffee contains many chemical compounds—even more than wine—that account for its complex flavor, and brewing a cup of coffee results in several physical changes. Water extracts each flavor from ground coffee at a different rate during the brewing process. As a result, the flavor of the coffee changes continuously as time elapses during extraction. Also, chemical reactions occur when brewed coffee is allowed to linger, often deteriorating its flavor.



WILL THE REAL ESPRESSO PLEASE STAND UP: Real espresso (left) and ordinary coffee (right), made on the same espresso machine. Though both were made with the same equipment, that does not make them both espresso.

As a general rule, the desirable parts of coffee (the sweet, flavorful compounds) are very soluble in water and easily extracted first. These parts also are quickly depleted from the

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ground coffee. The less desirable portions of coffee—the bitter elements, the acids and the caffeine—are less soluble in water and continue to be extracted as the water remains in contact with ground coffee. Prolonged extraction produces an unacceptable cup of coffee.

The aforementioned factors make it important to match the average size of the coffee's grind to the brewing process. The longer the water is in contact with ground coffee (about four minutes for French press), the more coarse the grind should be. Conversely, for shorter contact time, as in the case of vacuum extraction, coffee should be ground more finely.



A SHOT OF ESPRESSO

Espresso is about an ounce of heavy-bodied, syrup-like coffee concentrate with a thick, reddish-brown foam of tiny bubbles floating on top. This foam, or crema, that captures the intense coffee flavors is as important as the liquid concentrate underneath.

A modern pump- or spring-lever-operated espresso machine is required to deliver the hot, pre-measured amount of water to the finely ground coffee in the portafilter at high pressures (as much as 140 pounds per square inch) to make a real espresso. About nine grams of ground coffee is required for a single shot—exactly the same amount used to make a cup of ordinary coffee.

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This high pressure greatly accelerates the passage of hot water through the ground coffee, thus speeding up the extraction process and limiting the contact time. If the ground coffee particle size is matched to the shortened contact time with water, one can extract a very sweet and flavorful ounce of coffee. The desirable flavor components are extracted from the ground coffee, and much of the acids, bitters and caffeine are left behind in the

spent coffee puck. Unfortunately, it is still only a coffee concentrate, not yet an espresso.

To make real espresso, the oils contained in the ground coffee must be emulsified, in addition to extracting the solubles. This is accomplished by grinding the coffee finely enough and packing it tightly enough in the portafilter so as to impede the flow of water through the coffee, thereby forcing the water molecules to penetrate its particles, driving out these oils. The water's insoluble oils will form tiny droplets and swim in the coffee concentrate.

The resulting emulsification is what makes the coffee an espresso; it changes all the measurable properties of the liquid beverage as well as its flavor characteristics. Its density, mouthfeel, viscosity, surface tension and foam-forming ability are different from those of coffee or coffee concentrate. The oils in real espresso will coat one's taste buds and inhibit the ability to detect bitterness, resulting in a sweeter taste.

Thus espresso, when properly prepared, is a very different beverage from its coffee concentrate cousin. It does not take an expensive espresso machine to make a coffee concentrate, whereas the espresso machine is vital for the production of real espresso.

ESPRESSO: AN INTRINSICALLY SUPERIOR BEVERAGE

Because a shot of espresso and a cup of coffee are each prepared using the same amount of ground coffee and the espresso is prepared using much less water, coffee chemistry tells us that the espresso will be much sweeter. The cup of coffee extracts more of the undesirable parts from the ground coffee and hence will have more acids, more caffeine and more bitterness simply because more water remains in contact with ground coffee for a longer period of time. The emulsified oils and their effects on the taste buds tilt the sweetness factor much more toward the espresso, but this will not be true if the espresso is made as a three- or four-ounce shot.

Perhaps the most dramatic characteristic of the espresso is the role of the crema in our perception of coffee flavors. Crema consists of tiny bubbles with a layer of oil on their surfaces and aroma molecules captured inside. These crema bubbles are formed when the oils are extracted from the ground coffee particles at the exact moment when aroma molecules also are released, thus capturing the coffee's aroma in the cup instead of letting it escape into the room. There is no corresponding phenomenon to capture the aroma in the case of ordinary coffee.

When the espresso or espresso-based cappuccino or latte is consumed, these crema bubbles burst in the back of the mouth, releasing the aromatic vapors that ultimately find their way into the nasal cavity. These tiny droplets also attach themselves to the taste buds and burst from time to time, long after the espresso is gone, leading to the long aftertaste a quality espresso is known for.

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