grounds. Last, latch the portafilter onto the espresso machine gently in order to avoid jolting the grounds and breaking the seal between the coffee and the basket.

Perform the above actions quickly but carefully to prevent the portafilter from losing too much heat while it is unlatched from the group head.

*The Tamper*

The tamper should fit snugly into the portafilter basket. If the tamper is too small it will not seal the perimeter of the coffee bed, and channeling around the edges of the bed is more likely to occur. Ideally, the tamper should fit such that if it sits the least bit crooked, it will get stuck in the basket. I have had numerous tampers machined to fit my baskets and so far have found the ideal gap between the tamper and basket to be 5/1000 inch, i.e., a difference of 10/1000 inch (.25 mm) in diameter. A larger gap will create a slightly higher frequency of channeling over the course of many shots.

Custom tampers can be made by a local machine shop or by a tamper manufacturer willing to make custom sizes.

> Whereas most commercial tampers are machined precisely, portafilter baskets can vary tremendously in size; in a recent batch of triple baskets I bought from one supplier, the diameters varied within a range of 75/1000 inch, or 2 mm! I have found it is easy to find double baskets of consistent size and tampers designed properly to fit those baskets; I've had less luck with triple baskets. For triples my strategy has been to order dozens of baskets, measure their diameters to within 1/1000 inch, and return the baskets of exceptionally large or small diameter. Usually, the majority of basket diameters will be within a range of 2/1000 inch to 3/1000 inch; those are the ones I keep. Then I have a tamper machined to a diameter 10/1000 inch smaller than the smallest diameter in the range.
>
> Please note: a standard 58-mm tamper designed for single and double baskets does not fit all baskets equally and is not designed for use with triple baskets.

## Water Temperature

Brewing water temperature is very important because it affects flavor, brew strength, and flow rate. The "ideal" brewing temperature is determined by numerous variables, including the coffee used, the flow rate of a shot, and, most importantly, your taste. It is fair to say almost all professionals prefer temperatures in the range of 185°F–204°F.

A few established facts exist regarding the relationship between temperature and espresso quality.

- Excessively low temperatures produce sour, underextracted espresso.
- Excessively high temperatures produce bitter, acrid, burnt, and woody flavors.[21]
- Higher temperatures result in more solids extraction and body.[21]
- Higher temperatures result in slower flow rates.[9]



*Managing Brewing Temperature*

Before pulling a shot, a barista should purge, or flush, water from the group head to clear coffee particles from the dispersion screen and to manipulate brewing temperature. A flush can be done with the portafilter removed or with an empty portafilter latched onto the group head.

Some flushes are done to cool the group, some to preheat the pipes feeding the group head, and others to purge the *heat exchanger* of overheated water. Every machine is different and requires a customized flushing routine based on the machine's design, the desired brewing temperature, the *pressurestat* setting, and other factors.

*Managing Temperature on Multiple-Boiler Machines*

Multiple-boiler machines have one boiler dedicated to steam production and one or more thermostatically controlled boilers dedicated to brewing water. If it is well-designed and has a *PID (proportional integral derivative) controller,* a multiple-boiler machine can produce extremely consistent brewing water temperature every shot.

Such machines usually require a very short purge to produce the desired brewing temperature. The temperatures resulting from various purge amounts should be measured using a Scace Thermofilter or other bead probe thermometer.

The temperature profile produced by a thermostatically controlled machine is considered "flat" and looks like an "L" rotated clockwise 90°. Depending on the machine, it takes between a fraction of a second and several seconds for the brewing water to reach a constant temperature.

Flushing with no portafilter. Flushing can also be done with an empty portafilter in place to preheat it.

The Scace Thermofilter and Fluke™ multimeter

The steaming platform should be heavy but easily moved. It should be just tall enough that the tip of the steam wand is about ½ inch above the bottom of the pitcher when the wand is completely vertical.

promote inattention and inconsistency on the part of the barista. When done properly, the result should be no different from the result produced when the barista holds the pitcher.

With some espresso machines the drip tray is positioned well to act as a steaming platform, whereas with other machines it is better to have a heavy, moveable platform that can be easily slid in and out of place below the steam wand.

## Workflow

Busy cafés need to implement efficient systems for producing multiple beverages simultaneously. Such systems should be structured but flexible enough to accommodate different numbers of baristi working together. Most importantly, systems should be designed to optimize efficiency without compromising quality.



### *Efficient Workflow with One Barista*

Using the lessons described above I would like to outline an efficient system for use when only one barista is working. In this example, one 6-oz cappuccino and two 8-oz café lattes will be made using free-pouring and milk-sharing.

1. Start timer to grind first shot.
2. Fill 32-oz tapered pitcher with milk to ½ inch below bottom of spout.
3. Unlatch and knock out one portafilter, purge group, wipe basket, and dose.
4. As soon as all grounds have been dosed, restart grinder timer.
5. Groom and tamp first portafilter.
6. Attach first portafilter, remove second portafilter, and purge group.
7. Knock out second portafilter, wipe, dose, groom, and tamp.
8. Attach second portafilter, and set one latte cup and one cappuccino cup under portafilters.
9. Start both shots simultaneously.
10. Purge steam wand and begin steaming.
11. Once stretching phase is complete, set pitcher on platform.
12. Restart timer.
13. Unlatch third portafilter, knock out, and wipe.
14. Dose, groom, and tamp third portafilter.
15. As soon as first two shots are complete, stop shots and purge third group.
16. Attach third portafilter, set new latte cup underneath, and start shot.
17. Set first two cups on counter.
18. Turn off steam wand when desired temperature is reached. Wipe and purge steam wand.
19. Pour about ⅓–½ of the milk into a 20-oz secondary pitcher and trade back and forth until milk in secondary pitcher has appropriate viscosity for the cappuccino.
20. Pour cappuccino. Serve immediately.
21. Trade milk between pitchers until both pitchers have milk of equal volume and viscosity.
22. Pour first latte. Serve immediately.
23. Stop third shot when complete.
24. Set third cup on counter.
25. Pour second latte. Serve immediately.

With practice, a skilled barista can get used to simultaneously steaming, grinding, and observing shots. I advise baristi to work as efficiently as they can without sacrificing quality and to attempt to become more efficient over time.

### *Efficient Workflow with Two Baristi*

Busy cafés often require two baristi to work on the espresso machine together. This allows much faster drink production but can lead to coordination problems. As a general rule, one barista should pull shots, and the other should steam milk and finish drinks. The barista on the milk side has the more difficult job and should be the "lead," directing the flow and making decisions. The barista on the espresso side

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29. Smith, A. and Thomas, D. (2003) The infusion of coffee solubles into water: effect of particle size and temperature. *Department of Chemical Engineering*, Loughborough University, UK.

30. Illy, E. (June 2002) The complexity of coffee. *Scientific American*. 86–91.



# Glossary

**Acidity** The sharpness, snap, sourness, or liveliness of coffee.

**Alkaline** A solution with a pH greater than 7.0.

**Alkalinity** A solution's ability to buffer acids.

**Aroma** A quality that can be detected by the olfactory system.

**Bimodal** Having two modes, or values that occur most frequently.

**Body** A beverage's weight or fullness as perceived in the mouth.

**Bottomless portafilter** A portafilter with its undercarriage sawed off to allow viewing of the bottom of the basket during extraction.

**Brew colloids** Materials smaller than one micron in any dimension that are dispersed in a coffee. Made up of a combination of oils and cell wall fragments.

**Brew strength** The concentration of solids (or solubles) in an espresso (or coffee).

**Brewing ratio** The ratio of dry grounds to water used to make a coffee.

**Bypass valve** A channel used to divert a predetermined proportion of the brewing water around the grounds during drip brewing.

**Café crema** A very long pull of espresso.

**Channel** An area of high-velocity flow through a coffee bed.

**Compact layer** A densely packed solid mass that can form at the bottom of the coffee bed during espresso percolation.

**Concentration gradient** The difference in concentration of coffee solids from within the grounds to the surrounding liquid.

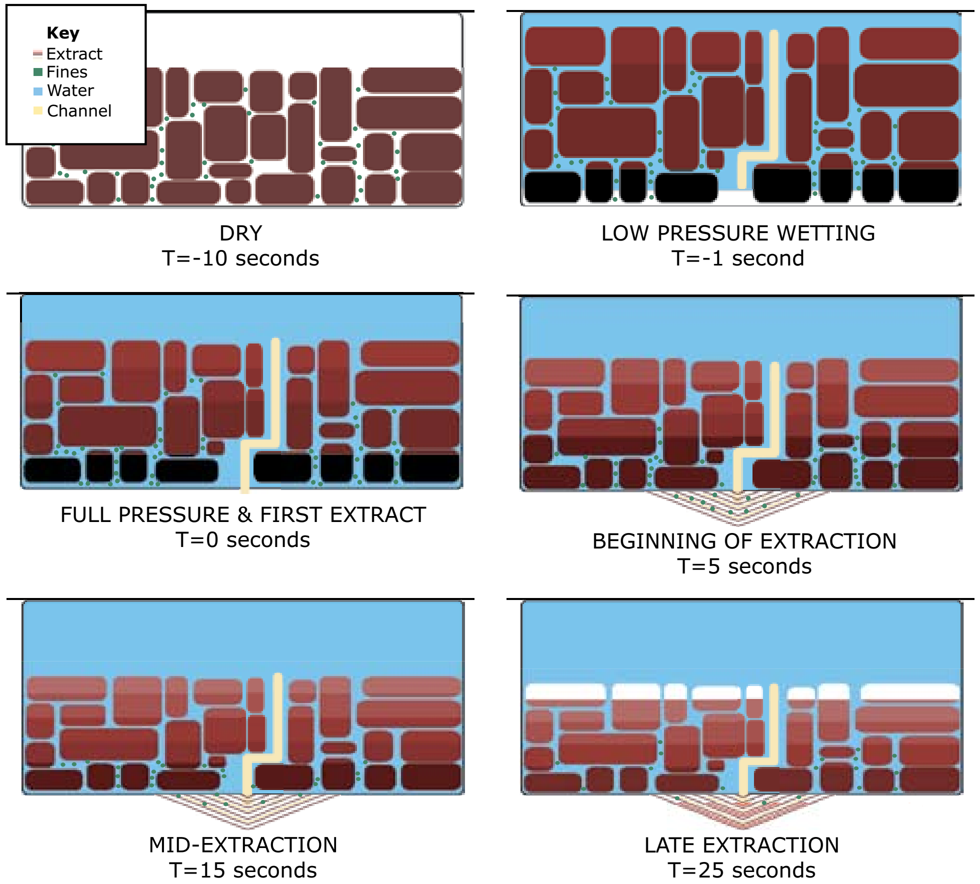
**Contact time (dwell time)** The amount of time the grounds and brewing water remain in contact.

**Crema** Espresso foam composed primarily of $CO_2$ and water vapor bubbles wrapped in liquid films made up of an aqueous solution of surfactants. Also contains dissolved coffee gases and solids, emulsified oils, and suspended coffee bean cell wall fragments.

**Cupping** A standardized procedure for evaluating roasted and ground coffee.

**Deadband** The difference between the actuation and de-actuation points of a pressurestat.

**Degassing (outgassing)** The release of gases, particularly $CO_2$, by roasted coffee




The color of the grounds (represented by the stacked rectangles) in the first frame is deep red, indicating they are concentrated with coffee solids. The lighter reds in later frames represent lower solids concentrations.

T = -10 seconds: *The dry grounds just before the pump is engaged.* The grounds are packed with solids, and fines are scattered throughout the coffee bed.

T = -1 second: *The coffee bed near the end of preinfusion.* The water has percolated through almost all of the coffee bed but extraction has not yet begun. The grounds have absorbed water, swelling the coffee bed. A channel, represented by the yellow line, has formed through the middle of the coffee bed. The upper layers of the coffee bed have lost solids, while the lower coffee bed has gained solids. Fines have begun to migrate down the coffee bed.

T = 0 seconds: *The first extract appears.* The first extract appears at the outlet of the channel. Fines and solids have concentrated in the lower layers of the coffee bed. The coffee bed contracts as pressure increases.

T = 5 seconds: *Early extraction.* Solids and fines are rapidly removed from the coffee bed. The coffee bed is further compressed as full pump pressure is applied.

T = 15 seconds: *Mid-extraction.* The coffee bed shrinks as it loses mass. The upper layers of the bed are almost depleted of extractable solids. The bulk of fines and solids are concentrated in the lowest layers of the bed.

T = 25 seconds: *Final moments of extraction:* The upper layers of the bed are completely empty of extractable solids. The coffee bed has lost about 20% of its original dry mass.



According to the research done with large percolator columns, diffusion does not occur until coffee particles are:

1. "Satisfied with bound water." Coffee particles can hold up to about 15% of their dry weight as bound water.[16]
2. Saturated with free extracting liquid.[7]
3. Free of gases.[7]

The typical espresso extraction time is probably too short for all three preconditions of diffusion to be met. Therefore, it is likely that espresso extraction is accomplished entirely by the washing of solids from the outer surfaces of coffee particles, as well as by the emulsification* of oils.[9] Diffusion plays little, if any role.

### *Flow Progression*

The initial extract from the flow of a well-prepared shot should be viscous and dark.‡ As the flow progresses the extract becomes more dilute and the color gradually lightens, eventually turning yellow. Cutting off the flow when it yellows, or

* The emulsification of oils seems to be enabled by the pressure of espresso brewing. It is arguable that the emulsion is the aspect of an espresso most responsible for differentiating it from a very concentrated cup of coffee.

‡ The color of the extract is believed to be darker when it has a higher concentration of caramelized solids or a lower concentration of $CO_2$, though there may be other factors that influence color.

Begin by pouring the milk into the center of the crema. Pour quickly enough to prevent separation in the pitcher but slowly enough to keep the crema intact.

Maintain a consistent, moderate flow rate throughout the entire pour. To do this, you must accelerate the tipping motion of the pitcher as the amount of milk in the pitcher decreases.

Rock the pitcher back and forth once the white cloud appears.

Continue rocking the pitcher to create a zigzag pattern. It is critical to resist the urge to raise the pitcher away from the surface of the beverage. It may be counterintuitive, but keep the pitcher as low as possible while pouring and constantly accelerate the tipping of the pitcher to maintain the flow rate.

Back the pitcher toward the edge of the cup while zigzagging. Once you reach the edge of the cup lift the pitcher a couple of inches and drizzle a small stream of milk back across the centerline of the zigzags.

*Ecco!*



### *How to Pour Latte Art*

To pour latte art you must have a fresh shot of espresso with a reasonable amount of crema and properly textured steamed milk. The milk should look creamy and glassy, with no visible bubbles.

The most common mistakes beginners make are pouring the milk too slowly and lifting the pitcher away from the surface of the beverage while pouring. Pouring milk too slowly can cause it to separate in the pitcher, causing less-aerated milk to pour into the beverage and more-aerated milk to remain in the pitcher. This makes pouring latte art difficult and also results in an under-aerated beverage. Raising the pitcher away from the surface of the beverage causes the milk to dive under the crema rather than resting on top of the crema and forming a design.

> Raising the pitcher while pouring prevents the milk from resting on the crema because the flow of the milk is accelerated by gravity. Raising the pitcher is analogous to diving from a high board: just as the milk dives to the bottom of the cup and hardly disturbs the crema, the diver cuts through the surface of the water with hardly a ripple and submerges deeply. On the other hand, pouring with the spout of the pitcher kept very close to the surface of the beverage is analogous to diving from the edge of a pool: the milk skims the surface of the beverage just as the diver merely skims the surface of the water.

### *The Spoon Method*

The spoon method is common in New Zealand, but I've yet to see it practiced elsewhere. The benefits of the spoon method include delaying froth separation in the cup and allowing control over the texture of the milk while pouring. The disadvantages of the spoon method are it takes more time than free-pouring, requires the use of both hands, and is harder to master.

The spoon method works best with a round bell or vev pitcher with a beveled edge. The wide mouth of the bell pitcher provides a better view of the milk texture while pouring and allows easier spoon access and control.

To execute the spoon method, steam the milk, groom it if necessary, and use a tablespoon as a gate to control the flow and texture of the milk as it is poured. The details are different for each drink, but the basics are the same.

1. Begin the pour with the spoon tightly restricting all but the densest, least frothy milk. Some baristi use the spoon to pull back (away from the pouring edge) the frothiest milk several times before restricting the milk and starting the pour.
2. Pour into the center of the espresso at a moderate rate to prevent breaking up the crema.
3. While pouring, lift the spoon slowly to allow frothier milk into the cup.
4. The surface of the finished drink should be glassy and can be finished with a design if desired.

## How to Milk-Share

Transfer about ⅓ of the milk from the large pitcher to the small pitcher.

Spin the large pitcher to check the milk texture before pouring.

Free-pour the cappuccino milk using the large pitcher.



Combine remaining milk in the small pitcher.

Spin the milk in the small pitcher. Groom if necessary.

Pour the café latte.

## Basic Tea-Making Guidelines

To get ideal infusions from a high-quality tea, it is necessary to become familiar with the tea's potential by experimenting with doses, water temperatures, and infusion times. It is also necessary to vary these parameters for successive infusions.

This approach might not be practical for most cafés, so I'll offer the following basic guidelines that will work well with the vast majority of teas.

*Dose*

For all teas, use 1 gram of tea leaves per 3 oz water. Volumetric dosing (i.e., using 1 tsp per cup) is not reliable because different teas can be of greatly varying densities. Fortunately, dosing by weight will decrease waste in most cafés since most baristi tend to use too large a quantity of leaves. To save time during service, I recommend pre-portioning tea leaves into small containers.

*Steeping Time*

Optimum steeping time is primarily determined by leaf size. Smaller leaves have more specific surface area and therefore require less steeping time. Larger leaves require longer steeping times; large, tightly rolled leaves need the most time to steep. Generally speaking, teas should be steeped until just before a significant amount of astringency begins to extract. Recommended steeping times range from 30 seconds to 4 minutes.

*Rinsing*

Some tea types require rinsing, as noted below. To rinse leaves, place them directly in the pot or use a coarse mesh strainer, such that any small tea particles can be flushed along with the rinse water. Fill the pot with water of the proper steeping temperature for about 10 seconds and then discard the rinse water. Gold filters, fine metal mesh filters, and paper tea bags prevent the flushing of small particles and should not be used for these teas.

*General Preparation*

Leaves should always be steeped in a preheated, enclosed container and be given ample room to fully expand. Tea balls, tea bags, and small strainers that do not allow the leaves to fully expand are not recommended. Teas with a lot of dust or broken leaves due to handling should be briefly rinsed to eliminate small particles.

The number of quality infusions offered by different teas varies. For any given tea the number of times it can be steeped well is influenced by steeping times and the ratio of leaves to water used. Higher ratios and shorter steeping times allow more quality infusions.

## Preparation by Tea Type

*Black*

Steeping time should be carefully managed because overextracted black teas quickly become very astringent. Most black teas offer one or two quality infusions and



should be steeped at 200°F–210°F. Black Darjeeling is one exception and should be steeped at 190°F–200°F.

*Oolong*

Always rinse oolongs before the first infusion. Oolongs can be steeped three to six times. The first steeping is often too bright or unrefined, the second steeping tends to be the most balanced, and thereafter each successive steeping needs a longer infusion time to extract enough flavor and strength. Steep darker oolongs (browner leaves) at 185°F–195°F and lighter oolongs (greener leaves) at 170°F–185°F.

*Green*

A few green teas, especially ones with rolled leaves or a lot of furry-looking "down," benefit from rinsing; experimentation is required. Due to the enormous variety of green teas and processing methods, ideal steeping temperatures can range from 150°F–180°F. Most green teas offer one to three quality infusions.

*White*

The delicate, subtle flavors of quality white teas are easily damaged by excessively hot water. Ideal steeping temperatures are 160°F–170°F, and most white teas offer two to four quality infusions. Whites generally do not require rinsing unless they have a lot of down.

*Herbal*

To prepare herbal infusions for optimal flavor, steep for 1–4 minutes. For the most potent medicinal benefits, steep for at least 10 minutes in an enclosed container. Steep most herbals in boiling, or nearly boiling, water.

*Other Teas*

Some teas, such as matcha, pu-erh, frost teas, yerba mate, and various aged teas require unique steeping methods and temperatures. These special cases are beyond the scope of this book, and I recommend that baristi research further before preparing them.

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