ROASTING SCIENCE

Looking Closely at Your Curves

by Kathi Zollman

We, as consumers, appreciate consistency.

We like knowing that when we step to the counter and order a double scoop of mocha almond fudge ice cream on a sugar cone, we will be rewarded with the same deliciously cold, creamy treat we know and love—there are no surprises, and we're never disappointed. Our heightened anticipation is matched with the consistent flavor from the first taste to the last, and we celebrate the experience. With this in mind, why is it that when we step up to the cupping table and begin the day's sipping and slurping, the coffee we loved last week tastes dramatically different this week—not even coming close to meeting our expectations of flavor and delight?

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To satisfy our curiosity about this altered flavor, we must go to the source of the difference, pinpointing the cause and correcting the variance to retrieve the much-appreciated flavor. This is a big task, but when armed with the right tools, roasters of all sizes can easily integrate a few key steps into a quality-assurance program. Diligence in record-keeping and best roasting practices can assure that our favorite Yirgacheffe is predictably bright and sweet with a twist of lemon every time it drops out of the roaster.

The first step in understanding the dramatic differences in a coffee is to cup it. That may sound like a no-brainer, but many roasters never cup their coffees, or they may not cup consistently. Cupping plays a significant part in quality assurance and building consistency of product, providing information to the roaster about each nuance the coffee brings to the cup. This is especially true when the coffee is roasted to the same color, but the roast profile experienced some variance in the path from start to finish. A visual inspection reveals that all is well with the roast; look for even roast color, full bean development and no hot spots on the bean. In most cases, a cupping evaluation is the only way to identify a problem before the coffee leaves the roastery. Or, even better, routine cupping can identify the best roasting results ever. If a coffee if roasted to perfection, having documentation of how it happened is even more important.

Cupping can be a quick evaluation of the flavor character; roasters can create a cupping form that best suits their needs to record their cupping notes. Complete and thoughtful cupping notes will make it easier to find a problem if one should arise later, but cupping notes can be as simple as a pass/fail system. Although cupping protocols may vary, it is important that roasters implement a protocol that suits their needs and carefully follow the protocol during each and every cupping session to ensure integrity of the process.

SAMPLE CUPPING NOTECARD

Carefully comment on the cup character as follows:

FRAGRANCE AND AROMA—Describe the smell of the ground coffee, both dry and wet. Some roasting taints can be found in the aroma and then confirmed when the coffee is slurped. Floral, spicy, sugary, medicinal, burnt, vanilla, meaty or fishy can describe the fragrance and aroma.

ACIDITY—Find words to describe the type of acidity in the sample as well as the degree of acidity. Is there a bright sparkle or harsh bite? Also note if the coffee is flat with a lack of sparkle. Describe the acidity as clearly as possible.

BODY—How does the coffee feel: thick, buttery, heavy, thin, light or watery? There are times when the acidity is so harsh that the body of a coffee can be masked.

FLAVOR—What does the coffee taste like? Is it perfect, or is there room for improvement? Does the overall flavor meet expectations? Good or bad, make easily understood notes.

After reviewing the cupping notes, we next look deeper to see where the roast profile varied. Roasters rely on records of past roasts to track many things. A well-developed roast log provides data for quality control, product development, and cost controls and can even help track down a problem with a specific roast. Roast logs can be efficiently completed by hand, by charting time and temperature along with other variables, or roasters can install software to assist with the logging of each roast. These logs will provide the information to track down the changes in the roast profile that are causing the inconsistency in cup quality.

Now, let's look at the curves and technique applied by the roaster. By reviewing roast logs and making comparisons, it is likely that there is a variance in the curve. The slightest change in the roast profile—as little as five degrees on either side of the desired profile—can be evident in the cup. Too fast, too slow, too hot or too cold, each change will affect the resulting flavor of the roasted coffee, positively or negatively. Chemists have identified hundreds of compounds in a single coffee bean; most of these compounds are chemically altered during the roasting process. These alterations can produce a range of flavor variables. A quick review of the Specialty Coffee Association of America (SCAA) flavor wheel shows the colorful variety of flavors found in the roasted cup, most of which are developed during the roast process. Bright, fresh, fruity acidity; rich, creamy caramel; spicy, warm clove—these flavors are all there under the roaster's control. The evil cousins to these same pleasurable results are flavors described as astringent medicinal, harsh bitterness, woody and burnt rubber.

To illustrate the range of roasted flavors in a single coffee variety, several coffee roasters were asked to participate in a roaster challenge. This small army of roasting daredevils was asked to take their favorite roasted coffee and then perform two more roasts, intentionally risking the results. The roast profile was drastically altered to obtain the resulting changes. Roasters were challenged to roast faster, slower and longer—breaking away from the preferred roast profile. These roasting facilities do not have access to scientific analytical equipment to measure the results of the roast variations, making this a very practical hands-on type of experiment. The results, however, were so obvious that an HPLC, or high-performance liquid chromatography, wasn't required to identify the resulting chemical changes. (In a food lab setting, tools like the HPLC are used to separate the mixture for the purpose of identification and quantification of the components found in each of the liquid coffee samples.)

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Simply cupping the coffees revealed both great and awful roasting results. Interestingly, when these profiles were repeated and cupped in a blind cupping, the cupping volunteers (consumers) were surprised to learn that there was only one coffee on the table. The differences in flavor, body and aftertaste were so dramatic that they assumed there were several coffees.

TECHNIQUE #1
"I forgot to turn on the heat"

This is a surprisingly common technique that occurs most often when roasters are distracted and forget to turn the heat on, or up, after the green coffee is dropped into the roaster. Phone calls and texting are a common cause for practicing this technique; the interruption of answering the phone takes the operator away from the task just long enough that the heat is forgotten. Then, about halfway through the roast time, full heat is applied, resulting in what is referred to as "catching up." The coffee turns the correct color and reaches the final temperature in the right amount of time. The S-curve for this profile would appear flat in the first half of the roast with little increase in bean temperature, with a sharp climb in the second half of the roast. The point of equilibrium was 150 degrees F; the slow start also produced a noticeably quiet first crack as a portion of the free moisture in the bean evaporates. The bean appeared to be well developed and had a slight oil sheen to it.

Common cupping comments: Light fragrance/aroma, little to no sweetness, flat acidity and a chalky alkaline aftertaste.

An exaggerated slow start to a roast with an extreme and aggressive finish did not produce a favorable cup result. When roasters experience a flat, chalky-tasting coffee, it could be linked to an extreme profile like the one experienced here.

Technique #1 Roasting Curve
Time vs. Temperature

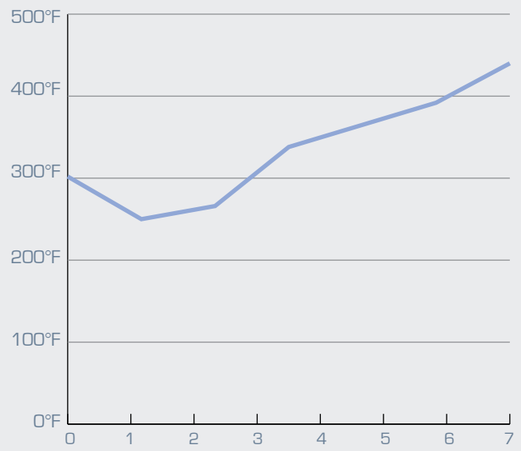
TECHNIQUE #2
"I have to roast a lot of coffee"

Many roasters feel the need for speed. Time is indeed money for any roasting company, and the more batches that are produced per hour, the better. Or, in some cases, the faster the work is finished, the sooner the roaster can go home. The fast-roast exercise was completed by dropping the coffee into a hot roasting environment at full heat. The application of full heat pushed the roast to completion in half the time of the control roast profile. The roasted coffee was dropped at the same temperature and looked pretty much the same as the other test roasts. A closer visual inspection revealed several scorch marks and some blowout marks from the extreme-heat environment.

The cupping results did not bode well for the hot-and-fast roast technique. The aromatics were pleasant and berry-like, more apparent than in Technique No. 1, but the attributes were less flattering as the cupping proceeded for this sample. One cupper experienced a severe case of "bitter beer face" after the first slurp, not expecting the cup to be so astringent and medicinal. The cup produced no sweetness, with harsh acidity, herbal flavor, very light body and a lasting aftertaste of dirt.

The fast roast produced an undeveloped-tasting coffee, making it difficult to identify what coffee was in the cup. The sweet caramel notes did not appear, and the fruit acids were masked by the harshness. Though production is nearly doubled using this technique, the coffee was very bitter and unpleasant.

Technique #2 Roasting Curve
Time vs. Temperature



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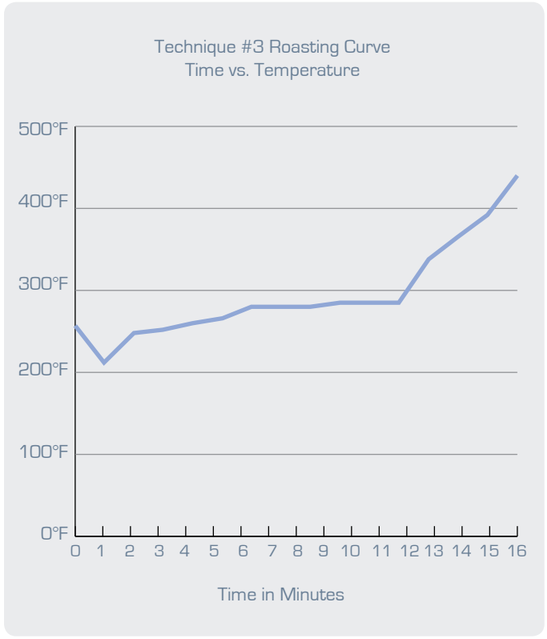
TECHNIQUE #3
"My roaster is too hot"

This roast technique involves a highly heated drum combined with minimal heat application to slow the roast down, which makes the roast appear to be controlled. This technique employed high initial heat with a point of equilibrium of nearly 250 degrees F and low heat application to prevent the coffee from gaining momentum and roasting too quickly. The heat was maintained at about 50 percent until first crack was reached; at this time, maximum heat was required to hit the desired time and final temperature of the roast profile. First crack was light with minimal noise. As with the previous two techniques, the coffee looked fine, with no reason to assume otherwise. The profile has a bit of an S-curve to it, and the prescribed time and temperature were reached.

Cuppers' notes included a range of descriptions for this technique. Aromatics included marshmallow and toasted nuts, even warm brown sugar. Other notes: a hint of sweetness, bittersweet chocolate, moderate acidity, slightly skunky by one cupper, aftertaste was lingering and slightly ashy. The body of this coffee was considered moderate rather than light, as in the first two techniques.

This was not a perfect cup as evaluated by the panel, but this technique did develop some of the sweeter characteristics of caramel and chocolate of the Maillard reaction. There was some improvement over the other samples, but it was still difficult to identify the coffee in the cup and even more difficult for the panel to accept that this was the very same coffee cupped in the previous round.

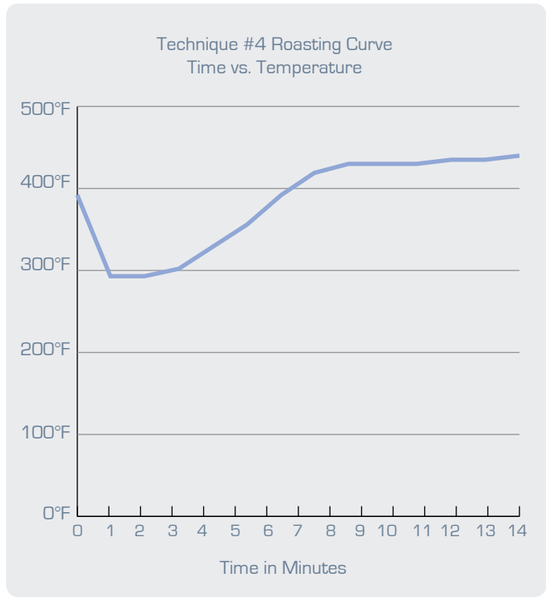


TECHNIQUE #4
"Can it get any worse?"

With this technique, the roasters were challenged to roast out everything good about the coffee. Can a roaster take a remarkable sweet and bright coffee and turn it into something that even the most skilled cupper can't recognize? The answer is simple: Yes. This technique starts out very hot, and then all heat is pulled as the beans dance around in the roaster. There is enough residual heat to keep the roast moving forward and not stalling out. One-third of the way into the roast time frame, the heat is introduced at 50 percent; a very dull first crack follows. Then at two-thirds time, full heat is applied to bring the roast in on time. The roast finished at the right time and the correct temperature. Good news for the roaster: the roast log looks great, the coffee has a dull look to it but otherwise looks okay—not too bad at all. The proof will be in the cupping. The S-curve looks slightly like a stair-step.

Cuppers' comments were not positive for this technique; the notes were blunt and pulled no punches. The aroma of the coffee was compared to burnt peat moss, compost and bitter dirt. After the break, one cupper noted a hint of roasted peanuts. No sweetness was found, flavor was nutty and slight. No acidity; the coffee was scored as flat, all sparkle was roasted out. Aftertaste was lingering compost, and body was described as watery by all cuppers.

This radical S-curve technique brought out the worst in this coffee, taking a very respectable sweet, bright and hard bean and transforming it into brown water that wasn't palatable. Yes, it really was that awful. This technique produced undesirable results and should be avoided.



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Roasting, or the application of energy, is what changes green coffee from a plain-looking, slightly fragrant bean to a desirable, complex, aromatic bean. The flavors are waiting to be developed and experienced. The changes the coffee goes through during roasting are both physical and chemical in nature. These changes are complex and occur at different stages along the roast path. Beyond the obvious color change from green to rich brown, other physical changes are observed. Most roasters have experienced first crack, occurring at around 385 degrees F; here, the coffee pops, sounding similarly to popcorn, and the coffee nearly doubles in volume in this phase. Other chemical changes are increasingly complex and occur within the bean. Optimum roasting conditions for these changes result in the formation of desirable coffee attributes.

Changes occurring during the roast are extremely complex and require a food chemist's knowledge to decipher. A very simplified model would identify the major changes as follows:

- Loss of water content—Green coffee has a moisture content of 10 to 12 percent; water is lost in the early stage of the roast, in the Maillard reaction, and finally during the dry distillation phase of the roast.

- Loss of weight—The darker the roast, the higher the loss of dry mass, ranging from 10 percent in medium roasts to near 20 percent in darker roasts.

- Decomposition of chlorogenic acids—Nearly 10 percent of the coffee bean's weight is made up of chlorogenic acids, a bitter tasting group of acids. When chlorogenic acids break down during roasting, two byproducts are quinic acid and caffeic acid, both known for bitter and astringent qualities. The entire CGA group is susceptible to change during roasting; 50 percent of the CGAs are destroyed and 80 percent are decomposed by the dark roast profile.

- Reconfiguration of sucrose—Nearly all the simple sugars are lost during the roast process, resulting in water and carbon dioxide, and flavor, aroma and color in the Maillard reaction.

- Decreased concentrations of amino acids and proteins—Proteins, amino acids and sugar combine in the Maillard reaction, resulting in some of the most enjoyable aromas and flavors found in roasted coffee. Caramel and chocolate flavors are considered to be a result of the Maillard reaction.

Simplified, yes, but the basic premise is achieved. With the hundreds of compounds developed during coffee roasting, there are also a few compounds that remain stable and unchanged. Lipids, salts, caffeine and a group of carbohydrates escape change in roasting. There is plenty of room for error, but also room for great success for coffee-roasting enthusiasts wanting to take the rather bland green bean and roast it to something wonderful, unlocking all the secret flavors and textures hidden within the walls of the bean.

Managing roasting techniques and practicing cupping as a part of a quality-assurance program will assure the consistency we all appreciate and eliminate most of the surprises. An untested coffee shouldn't leave the roastery if there is even the slightest chance that it could vary from the best profile. If the favorite Yirgacheffe coffee from last week is not the same lemon-sweet, sparkling coffee this week, a quick review of the roast log will help isolate the potential problem. Too much heat, too large of a batch size, not enough heat—there are so many ways for trouble to brew.

Roasters need to become experts at cause and effect; if something negative is happening, what can be the cause (or causes)? Use the extreme roast techniques illustrated here as a reference point for corrective changes to the roast profile. For example:

- If the coffee tastes flat, not quite as bright as you remembered it being, look at the first portion of the roast. If the curve is flat with little temperature increase before it starts to climb, the acidity could be flattened out and the bright sparkle will be lost. Some loss of aromatics might also be noted in this scenario.

- If the sweet coffee has lost its sweetness and tastes bitter and harsh, look at the point of equilibrium and the application of heat. These characteristics can be associated with too much heat too soon and too fast of a roast. These beans might also appear to be unevenly roasted.

The four roasting techniques described are exaggerated but also very real, with each one taken from an actual roasting situation. Taking roasting shortcuts typically results in a variation in the final product, even when it visually appears to be identical.

Consistency in product is essential to customer satisfaction and retention, wholesale or retail. Creating a consistent product requires record keeping and a quality-control protocol that becomes the rule, not the exception. There are literally hundreds of opportunities for the coffee to be amazing, so roasters shouldn't leave it to chance. Take time to control the outcome with proven roasting techniques for each coffee and be accountable to the practices. The cupping table results will support the sound roasting practices, and you can be confident that when your customers place an order for their favorite coffee, the beans will meet or exceed their expectations.

KATHI ZOLLMAN, *assistant director of specialty green coffee sales at Coffee Holding Company, is a frequent presenter at a variety of roaster education venues. She has shared coffee-roasting skills at Roasters Guild events, the annual SCAA Conference, Coffee Fest and multiple regional roaster gatherings. Specializing in blending, sensory skill-building, and profile roasting and manipulation, she continues to be a student of all things coffee.*