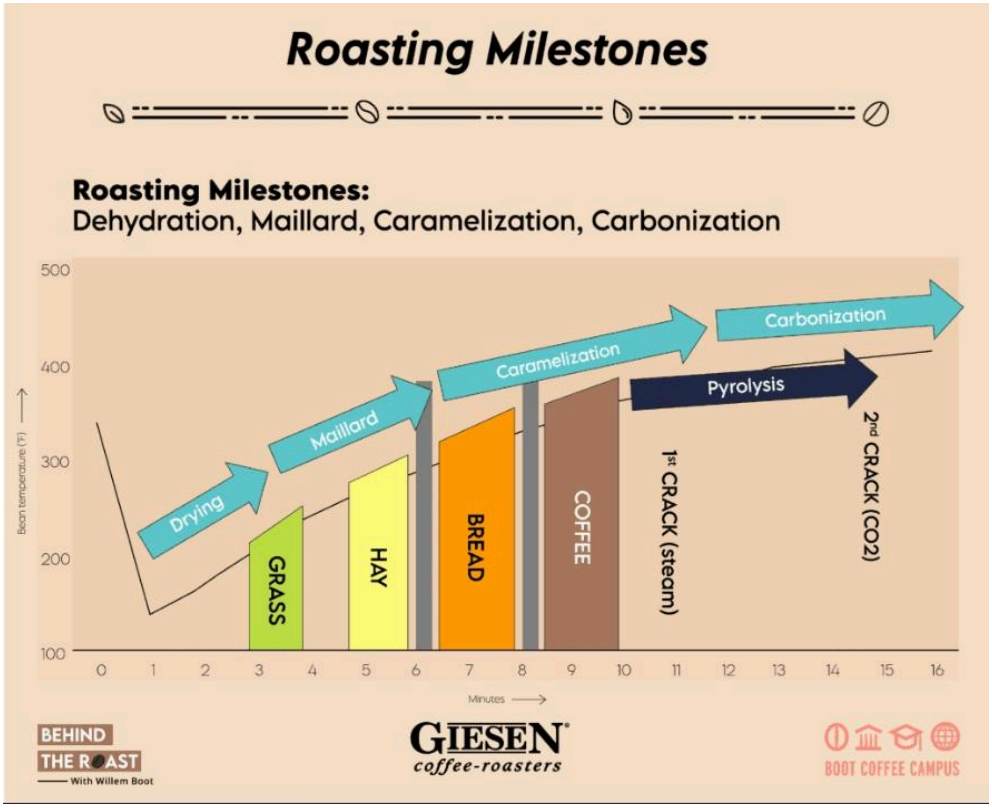
Xanadu Roast Module 2: Post-Crack Development

When coffee is roasted, it undergoes a number of chemical changes that can be distinguished by various sensory cues. Two of the most distinctive indicators of how beans are changing during the roast are the temperature thresholds known as first and second crack. The two “cracks” are named for their audible popping sound, and typically occur at 385°F and 440°F, respectively .

What Is the First Crack?

While roasting, coffee beans undergo a series of chemical reactions, both endothermic and exothermic, as a result of heat transfer. Heat energy from the drum and hot air moving through the roaster and is absorbed into the beans. This is the cause of the endothermic reactions. This initiates a reaction between the amino acids and reducing sugars (called the Maillard reaction), which creates a range of flavor and aromatic compounds within the beans. The Maillard reaction accelerates between 250°F and 300°F, before slowing down when the bean temperature reaches approximately 340°F, giving way to caramelization. Caramelization is a form of pyrolysis (chemical decomposition as a result of heat) that decreases sweetness and increases bitterness in the beans.



William Boot , Boot Coffee Campus

Up until this stage, the beans have been absorbing heat energy and building up internal pressure. At around 385°C, the water vapor in the beans builds to a critical mass and explodes out of the bean emitting a cracking sound from within the drum, not unlike the sound of corn kernels popping. This is called “first crack”.

At this stage, the beans enter an exothermic reaction, releasing built-up energy, steam, and carbon dioxide (CO2) from their core. They spontaneously expand and expel chaff, and start to give off smoke. When monitoring the roasting process, it’s important to note that first crack is defined as the point when all the beans in the chamber begin to crack, rather than just the first few beans.

What Is Second Crack?

After the first crack, a short endothermic phase follows. The color of the coffee continues to darken, while gas and pressure start building up within the bean once more. During this phase, the cellulose structure of the bean continues to break down and becomes more brittle, paving the way for a second crack. When second crack occurs (typically around 435°C) the oils within the coffee beans start to migrate to the surface. The roasting smoke also becomes darker and more pungent. This is characteristic of dark roast profiles.

It’s important to carefully monitor this stage of the roast as the character of the beans begins changing at a rapid rate; if left for too long, they may even ignite. Roasting too deep into second crack will mask even the stronger and more distinctive flavors of your beans. Instead, they will start to taste burnt and smoky, with muted acidity. Later after a second crack, they can even start to taste like charcoal as the body of the coffee decreases.

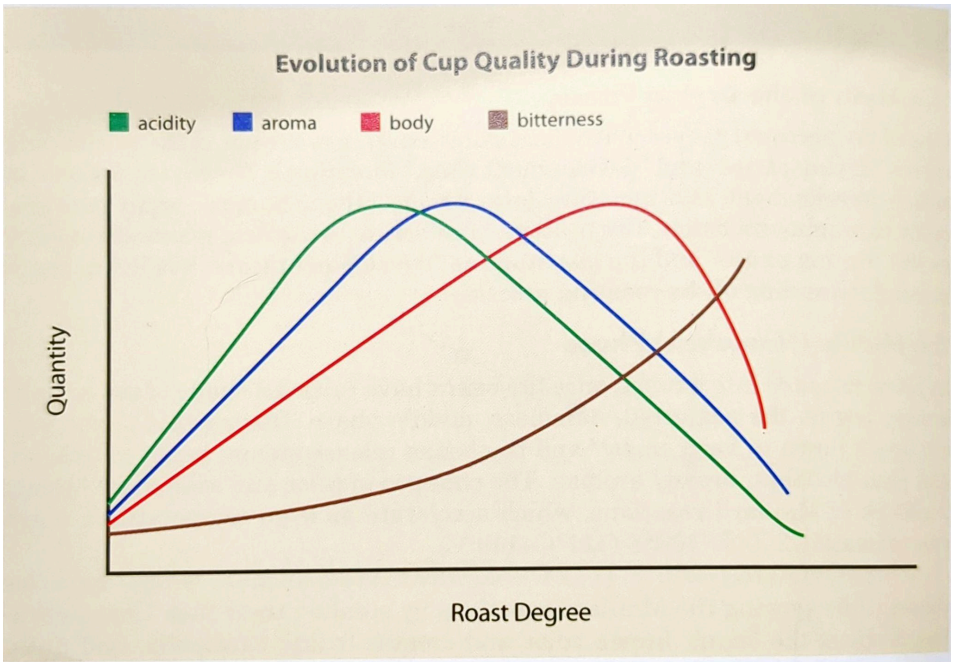
WHAT IS BEAN DEVELOPMENT AND WHAT CHANGES OCCUR?

Technically, the bean is always developing, from the moment it enters the drum to the moment it is ground and immersed in water for brewing. During the roast process, once the water vapor has been forcefully propelled from the bean at first crack, the coffee now experiences rapid development and the inside of the bean quickly begins to match the outside of the bean in temperature and caramelization. For this reason, roasters refer to this development ‘stage’ as post-crack development, or PCD for short, and is tracked meticulously during the roasting process.

In the book, Home Coffee Roasting, Kenneth Davis explains that dropping a coffee around the first crack will result in a cup that is “acidy and sweet but also tealike.” Continuing past this

point, more sweetness can be developed through further caramelization of sugars. The longer the development, the more the sugars in the coffee will darken, causing a stronger flavor of burnt-sugar bitterness. Coffee can develop a myriad of profiles depending on how it's roasted. Understanding the specific faults that can occur while roasting will help avoid certain undesirable effects on flavor.

Flavor Development, The Coffee Roasters Companion , Scott Rao



Acidity increases during roasting until the beans reach a city roast and declines with further roasting. Aromatics peak shortly afterward, in the range of city to full city roast. Body increases until a roast reaches a very dark color somewhere in the vicinity of French roast, after which body declines. Extraction potential is maximized at a French roast and decreases thereafter as pyrolysis burns off soluble mass.

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ISSUES IN THE DEVELOPMENT STAGE

1. PCD too short: the coffee has been released from the drum before the desirable attributes have properly developed. Visually the coffee will be lighter colored than it should be, denser, and higher in moisture. Oftentimes it is the inside of the coffee that has not had a chance to fully develop. This is referred to as underdeveloped coffee, and causes grassy-like flavors in the cup.
2. Drop temp too low: If the drop temp is too low, caramelization has not had an adequate chance to fully develop the flavors inside the coffee bean . This is referred to as baked coffee and results in dull, bready or 'oaty' flavors in the cup.

3. PCD too long or Drop temp too high: Overdevelopment is a pretty contentious topic in the roasting world. Even Kenneth Davis has said, “there is a small margin between a dark roast and overdevelopment. Everybody has a different palate, and a dark roast for one person may be overdeveloped for someone else.” Knowing what you or your customer wants is the key to stopping the roast before overdevelopment occurs.

DEVELOPMENT TIME RATIO OR DTR: USING DEVELOPMENT STAGE AS A TOOL

Roasters with software can judge the roast degree in terms of development time and development time ratio.
Development time ratio is calculated after the point of first crack, expressed as a percentage of the total roast time. Development time ratio helps roasters understand roast time in relation to their own roaster. Each roaster has different batch sizes, mechanisms, and temperature conditions which will result in different temperatures and readings. Development time ratios allow roasts to be compared more accurately and use at least one indicator for a more general consensus. This is helpful for those who have roasted coffee to their liking and wish to imitate it.

Experimental Outline :

We will roast 3, batches using our Ikawa sample roaster on medium drip profile setting. Each profile will progress to the first crack point as closely as possible. From the start of first crack we will develop each profile with 7% differing DTR’s starting with 7% DTR while also trying to match the end temp on each profile.

Roast 1 : Total Roast time is 7 min. DTR is 7%. End temp 400 F
Roast 2 : Toast Roast is 7 min. DTR is 14%. End temp 400 F
Roast 3: Toast Roast is 7 min. DTR is 21%. End temp 400 F

Each sample will be cupped the next day and evaluated for underdevelopment or overdevelopment.

Expected results

Pretty straightforward on this one. We normally roast 15-20% so I am expecting the 14% DTR to be the best profile on the cupping table. The 21% will probably be fine, with more bitter, roasty notes . The 7% DTR I am expecting to be pretty gross, grassy and hay-like.