The Mathematics of Coffee Roasting

Presentation to Math Club

Robb Sinn

March 26, 2025

Great Tasting Coffee

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- Whole coffee beans (unground) go stale within 12-14 days.

Coffee and Sweetness

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Cousin to the Cherry

The coffee "bean" is actually the seed part of a plant similar to the cherry plant: like a peach or plum. The pit is surrounded by the pulp which is delicious: fruity and sweet.

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These audible cracks along with the color and scent of the beans allow the roaster estimate which chemical changes have occurred and, thus, how the flavors are developing.

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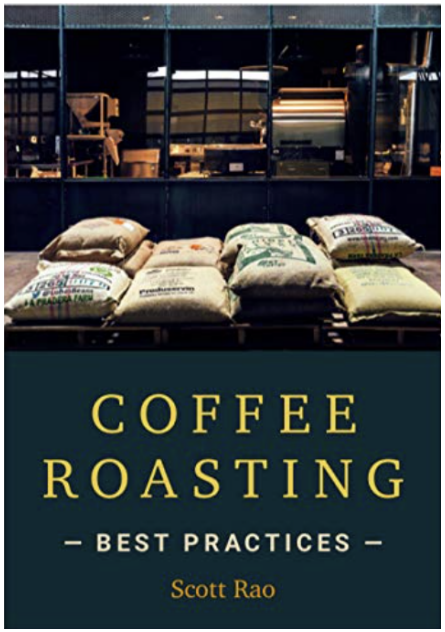
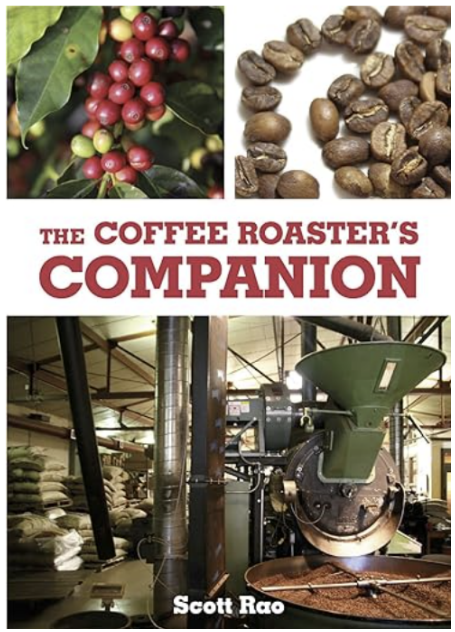
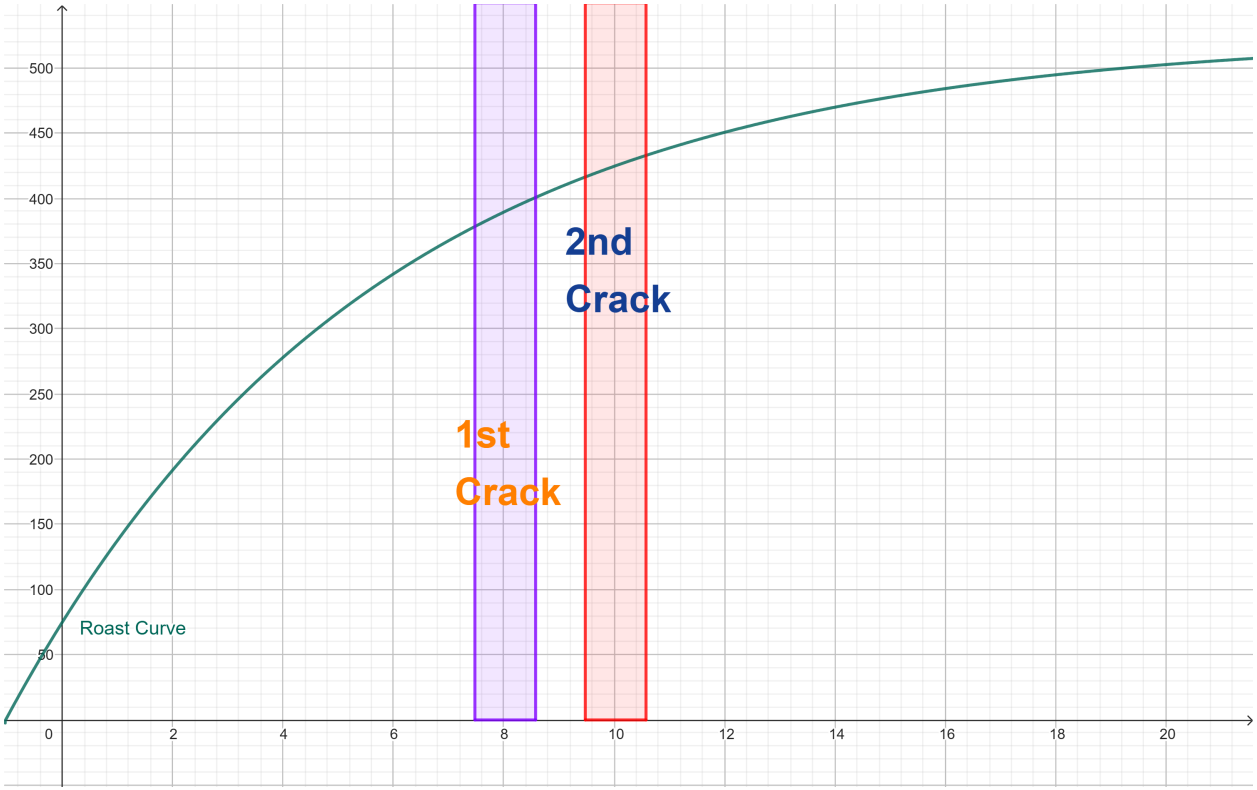




Roast Curve

The **heat curve** measures the approximate temperature of the beans during the roasting cycle. The **rate of rise** refers to the steepness of the slope of the heat curve.



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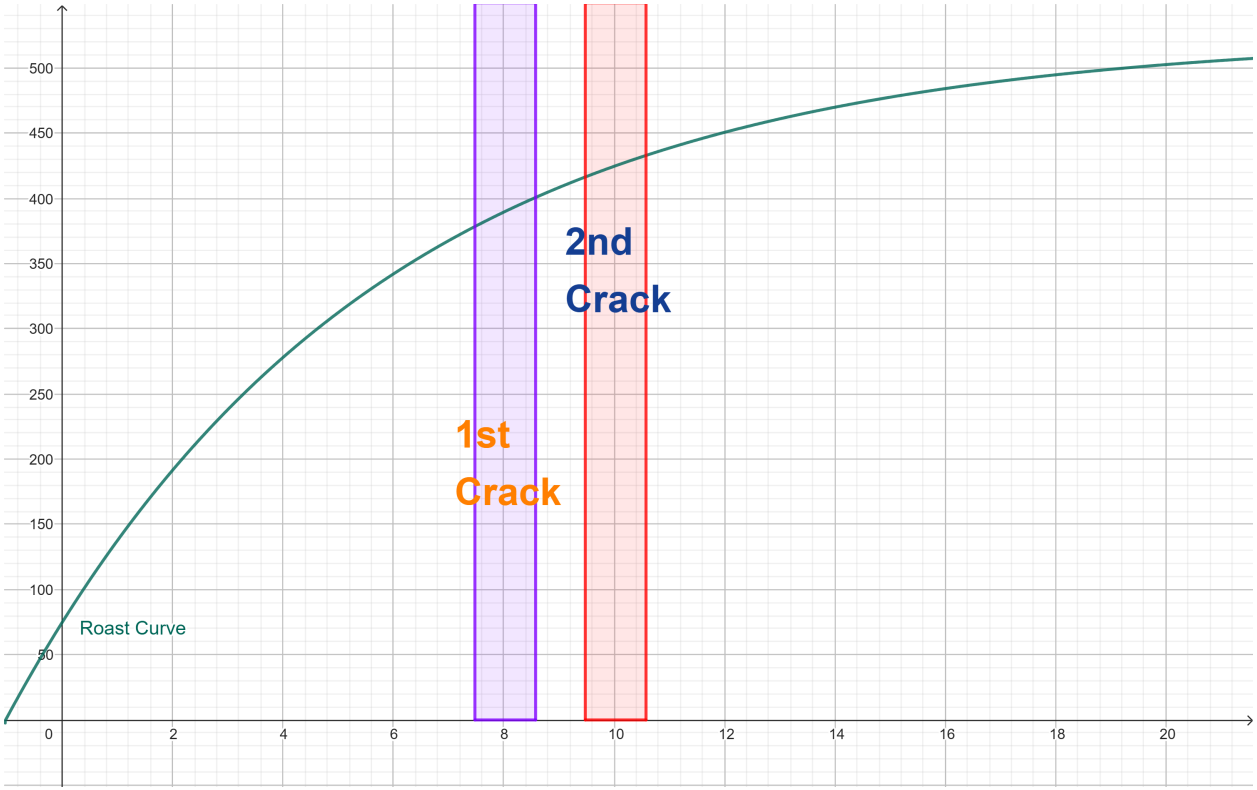

The question to be asked:

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The 1st and 2nd cracks ring out as audible indicators of where we are in the roast development and when we should end the roast.

The Chemistry of Coffee Roasting

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So much sugar! Yes, coffee beans are naturally sweet with notes of berries, nuts, citrus fruits, herbs, spice and chocolate.

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Green coffee beans have different moisture content, density, size and shape. All these factors play into how a roast develops.

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I think of the stale **coffee snarl** as hot, dark, bitter and soulless: the taste of "Here comes my caffeine" but nothing much else.

How the Coffee Bean Changes during the Roast

Scott Rao in *Coffee Roasting: Best Practices* highlights the changes in the beans during roasting. The beans:

- Lose moisture.
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Individualistic

Different beans have different characteristics, each of which can have an impact upon the roast development.

Roasting Curves.

We hope to develop specific flavors as we roast. The shape of the roast curve (**slope, concavity**) makes that either more or less difficult.

Steep, Linear Curve. If heat is added too quickly, little or no separation exists between 1st and 2nd crack. The chemical changes occur in a rapid jumble that spins the roast out of control.

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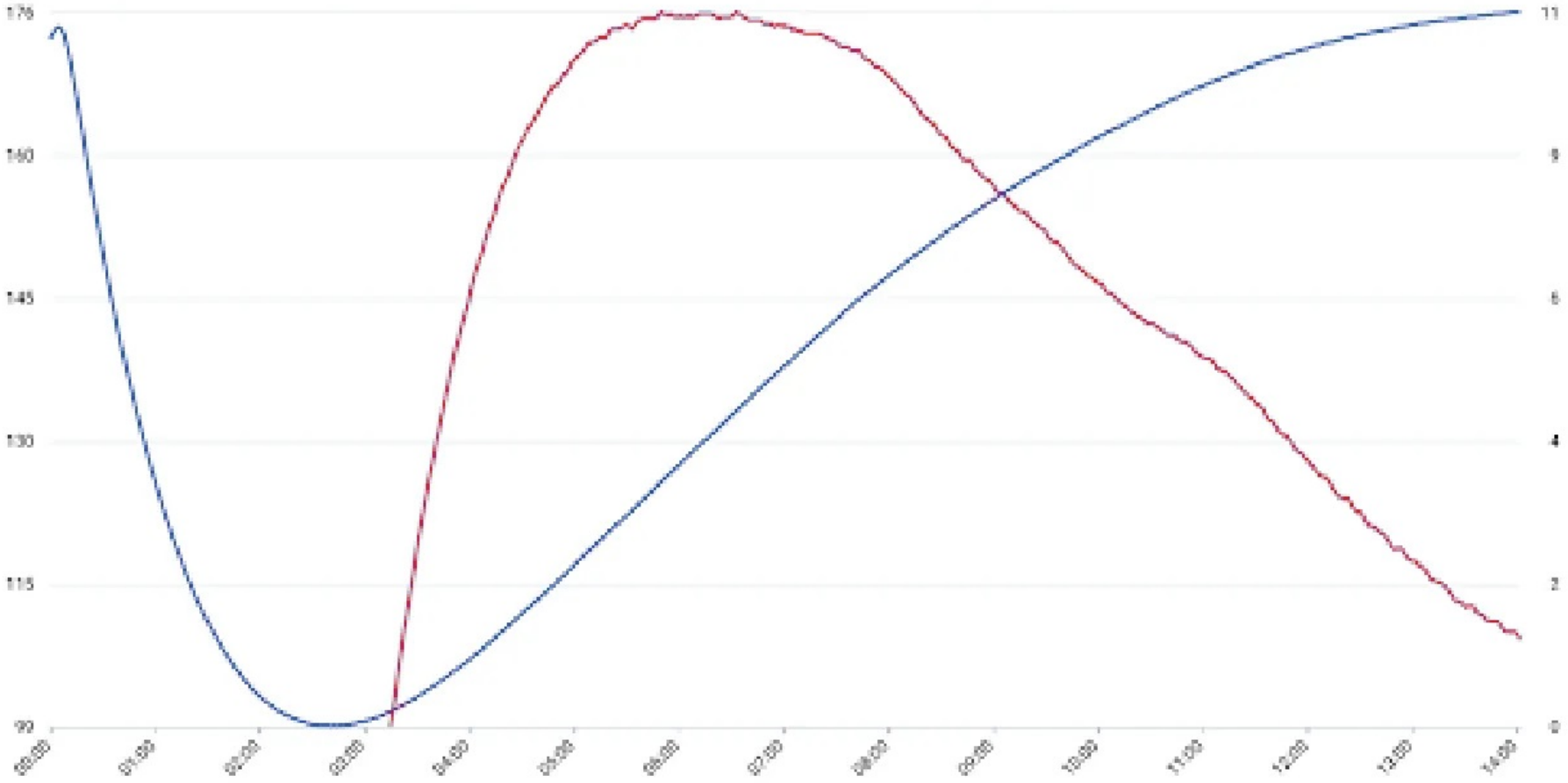
We prefer a steep, positive slope to the curve below 350° and a shallow, positive slope during and between the cracking phases.

Actual Temperatures during a Roast

The BLUE curve is the roast temperature over time.
The RED curve is the rate of rise.



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- The **finishing temperature** of the roast is vital. The maximum temperature of the roast occurs at the very end. Thus, finishing temperature controls which chemical changes have been initiated and which have not.

Additional Difficulty

Control of the roast depends on tight control of roasting temperatures.

Coffee Beans are Difficult to Cool

Coffee beans, once heated, retain their heat well. The outer portion of the bean is a husk. It can seem like each coffee bean has its own blanket.

The issues caused by the heat-holding nature of coffee beans include:

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