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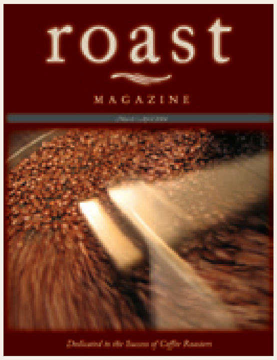

This article was originally published in the March/April 2004 issue of *Roast*

RULING THE ROAST

The Naked Bean

Roasting to Perfection

by Willem Boot

FOR ME, roasting coffee is as meaningful for my personal fulfillment as it is critical to the creation of an aromatic cup of coffee. My personal journey with roasting started at the age of 14 when my father built the prototypes of his "Golden Coffee Box" home coffee roaster. A few years later, I learned roasting on a vintage L12 batch roaster, which required the use of the most sophisticated and valuable measuring tools a human being has: sight, sound and smell. The many hours I spent roasting coffee in the artisan way were inspirational and challenging at the same time.

The inspiration comes from the satisfaction of creating a final product, from turning a tasteless green bean into a lively aromatic roasted coffee. In my experience, the challenge with roasting has always been connected to the intricate desire for perfection, from the quest of roasting the beans just right to that defining point of maximum flavor in the cup. A colleague described the challenge of roasting in an interesting way: "Imagine sailing a yacht in eight-knot winds, and instead of lowering your sails, you steer the boat right at full speed past the entry buoys, into the harbor, just left of the main pier. When you arrive at your dock you steer the yacht 180 degrees into the wind, which stops the boat completely and brings you home safely."

Coffee roasting is just like this scenario. In the roasting process, coffee beans are first loaded with energy until the heat-absorption capacity of the beans is nearly exhausted. Right before spontaneous combustion becomes inevitable, the roaster operator reduces heat input and allows for a gradual increase in bean temperature. Finally, at the end of the roasting process, the bean temperature needs to drop about 350 degrees as quickly as possible during the cooling process. For understandable reasons, outsiders might think that roasting is like the ultimate balancing act: risky and hazardous.

However, with the proper amount of control, coffee roasting can be as safe as toasting bread or barbequing a burger.

Despite all these modern controls, many roasters are still confused about how to use their roaster with different bean types and how to design time temperature profiles to get the best possible outcome in the cup. To develop the proper skills of controlling your roaster consistently, it is important to understand how parameters like moisture content and bean density influence the roasting process.

How Green Coffee Quality Affects Roasting

Moisture Content

In roasting, the moisture content of the green bean plays an important role. Under normal conditions, green coffee beans have a moisture content of 10–12 percent. The moisture content will fluctuate freely with the relative humidity content of the ambient air. In cities like Amsterdam and San

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Picture A.
Kenya coffee bean: hard bean structure

Francisco, relative humidity levels throughout the year are nearly perfect for storing green beans over a length of time, and for slowing down the aging process of green coffee. This also reduces the likelihood that the roaster operator has to change roast profiles to compensate for possible variances in green coffee moisture.

The moisture inside the green beans is partially free or is present as bound moisture and contained in the carbohydrate molecules.

We can summarize the roasting process as a three-stage cycle:

The drying phase is when the moisture content of the coffee is reduced to about two percent. During this phase, the "free" moisture—the residue of the process from cherry to green bean—evaporates. Free moisture also plays a role in the heat transfer during roasting. As soon as the beans are energized with heat, the bean's moisture conducts this heat throughout the bean. When the internal bean temperature approaches 212 degrees F., the free moisture starts evaporating.

In the second phase, from the first crack to the second crack, coffee beans develop their specific aromas and flavors, which, as coffee tasters know, can produce a very complex taste profile. At the end of the second phase, all free moisture has evaporated. The length of the second phase depends on the roasting degree, which can vary from region to region and from product to product.

With very dark roasts, there is also a third phase which starts when the second crack is almost completed. During this phase, carbonization takes place and the bound moisture is destroyed.

Beans with a moisture content of less than 10 percent have a sharply reduced free moisture level and will tend to roast much faster, especially in the first phase. In this case, the roaster operator needs to change the roasting profile by initiating the roasting process at a lower heat level and by maintaining a lower amount of energy supply (less BTUs) during the first roasting phase.

Beans with a high moisture content (fresh crop coffees can have a moisture content in excess of 14 percent) often require that the roaster operator includes a pre-drying phase before starting the first phase of the process. During pre-drying, it is recommended that the roaster maintains a drum temperature of 300 degrees F. with the objective to slowly remove the excess free moisture. The actual phase one of the roasting process can begin as soon as the beans start losing their deep green color.

CELL STRUCTURE DENSITY

Lower grown beans generally have a less solid bean structure than higher grown beans. The density of the bean structure is revealed by the shape and the position of the center cut. Picture A (shown above) shows a bean from Kenya, which was grown at an altitude of at least 5,500 feet. The center cut is tightly closed and almost seems to be floating in the upper layer of the bean. In sharp contrast, Picture B (shown right)

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Picture B.
Robusta coffee bean (Indonesia): soft bean structure

displays a robusta bean, grown at almost sea level. In this case, the center cut is widely opened and draws like a deep crevasse through the coffee bean.

What is the relationship between bean density and roasting? High-density beans have a denser cell structure and more cells per cubic millimeter than low-density beans. As a result, high-density beans are more resistance to heat, which will be especially noticeable during the first phase of roasting.

After the evaporation of free moisture, the color of the coffee beans starts changing from (light) green to yellow to light brown. During this color change, the bean starts expanding. With lower-density beans, the center cut will open more quickly, allowing for a faster transfer of heat, which will accelerate the process even further.

Green Bean Types and Time Temperature Profiles

To develop an effective roast protocol, I recommend dividing green coffee beans into the following four categories:

I). Hard bean types: Roast these coffees with high initial heat and moderate heat in the final stage of the roast process. Examples: Kenya AA, Guatemala SHB and almost any coffee grown higher than 5,000 feet.

II). Medium hard bean types: Roast these coffees with moderate initial heat and moderate heat in the final stage. Examples: Brazil, Sumatra, Java and most Latin American coffees grown lower then 5,000 feet.

III). Soft bean types: These coffees should be roasted with low to moderate heat during the entire process. Example: Hawaiian coffees, Caribbean types and beans grown lower than 3,500 feet.

IV). Fresh-crop coffees: These coffees normally have a bean structure that is not settled or hardened yet, especially if the coffee did not have its required resting or curing time. During the first 3–5 minutes, the operator should maintain a moderate roasting temperature, after which the roasting cycle can be continued according to the category indication that was described before.

Following a normal roasting pattern for medium-hard beans, pictures C, D and E (see pages 4–5) show the external development of the coffee beans during the roasting process.

The next three pictures F, G and H (see page 6) display the internal development of the same coffee beans. In this case, the roaster operator should attempt to obtain an almost linear roasting curve, with the internal bean temperature increasing proportionally with the roasting time. Notice the remarkable bean expansion shown in picture H. During roasting, coffee beans expand dramatically, and their volume can increase with more than 75 percent.

Roasting Profile for Hard Bean Coffee

For hard beans, especially when roasted beyond the second crack, I recommend an "S-curve" for the roasting process. (This is based on endless cupping trials and

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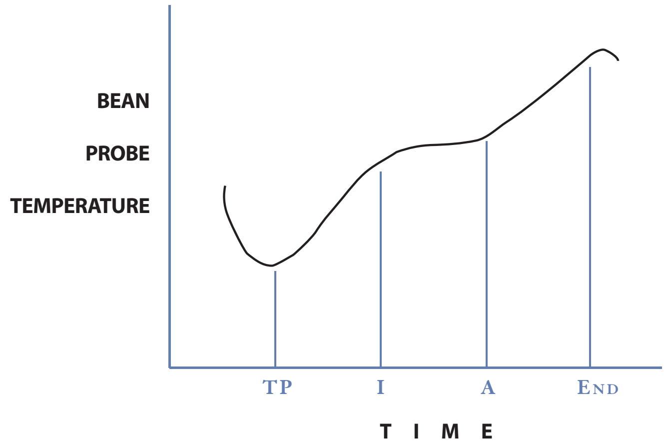
Picture C.
Kenya bean, after 3 minutes roasting

comparison of different roast profiles).

The following graph illustrates the corresponding roasting protocol for a hard bean:



After loading the beans into the drum, the bean probe will display a drop in temperature, which will bottom out at the turning point (TP).

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Picture D.
Kenya bean, after 6 minutes roasting

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Picture E.
Kenya bean, after 11 minutes roasting (after the first crack)

Hard beans will now be roasted with high initial heat. Until the start of the first crack, the heat inside the beans is endothermic; the beans are absorbing the supplied heat.

Right before the start of the first crack, the heat inside the beans becomes exothermic and the beans start generating heat. At this point the operator has to reduce energy supply in order to gain control of the roast process (point I).

After about two minutes of controlling the roast with low energy supply (less BTU), the operator can again increase heat (endothermic heat; the beans are again absorbing heat) to prepare for the finish of the roast. The start of energy increase can be seen at the point where the temperature curve is rising again (point A, see page 35).

During numerous cupping trials, I have found that the ideal time between the start of the first crack and the end of the roast (I and End) is at least three minutes.

The ideal roast time for solid drum roasters with convection heat (airflow heat passing through the drum) is 12–15 minutes. With these roasters, roast times longer than 20 minutes will produce baked flavors; roast times shorter than eight minutes will enhance sour notes. For solid drum sample roasters, the roast time can be done in 8–10 minutes.

Drum roasters using infrared heat usually allow longer roasting times without affecting the quality of the roasted coffee. Fluid-bed roasting machines, which use the concept of transferring heat through a high-velocity airflow at a reduced temperature, usually allow faster roasting times.

After learning roasting the hard way—by using sight, sound and smell—I later discovered the important value of proper measuring tools, such as probes for exhaust, environmental and bean temperature. Anyone who operates a coffee roaster can replicate the experiments I've completed over the past years. Learning how to roast each green bean to perfection is just the first step in creating that perfect cup

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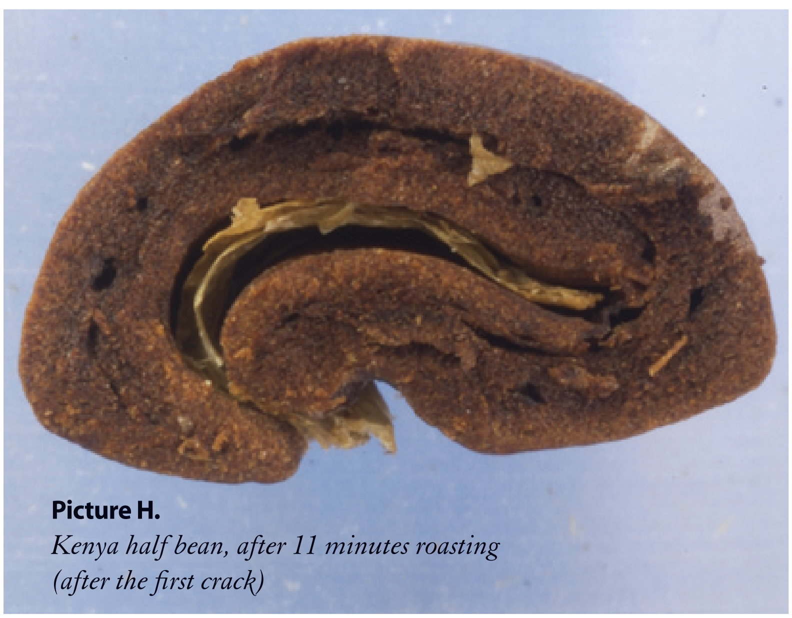
Picture F.
Kenya, half bean, after 3 minutes roasting

Picture G.
Kenya half bean, after 6 minutes roasting



Picture H.
Kenya half bean, after 11 minutes roasting (after the first crack)

of coffee. In all cases, a stringent cupping protocol should determine the optimal roasting profile of your coffee.

Coming Next Issue

In the next issue, I will discuss roasting defects and how to prevent them. Specific roasting questions can be submitted by sending an e-mail to *wboot@bootcoffee.com*.

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