## The physical changes during coffee roasting

The roasting process transforms coffee from a green seed to the aromatic, flavourful bean we love.

When we roast coffee beans, they undergo physical and chemical transformations.

## The Importance of The Physical Structure

The anatomy of a coffee bean is essential to creating the delicious roasted end product we want. Without the specific physical structure, the chemical reactions essential for flavour and aroma wouldn’t take place.

Ground green coffee powder exposed to similar temperature as in bean roasting does not produce the desired flavour compounds. The intact bean acts as a ‘minireactor’ for the chemical reactions. It controls the reaction environment in a way that the right precursors can react with each other in the right sequence.

## Dramatic Changes

Green coffee beans are dense and compact seed structures. But when you introduce them to the roaster, their native form is completely changed.

### *Colour*

Perhaps the most obvious change that happens during roasting is in colour. Before roasting, coffee beans are blue-green. They change to brown because of the production of **melanoidins**. These are polymers that form when sugars and amino acids combine under heat. Chaff, or silverskin, will also come off during roasting. This is the papery outer layer of the coffee bean.

Roasters and consumers use the level of colour as a parameter of quality and profile.

### *Moisture & Mass*

Water makes up around 10–12% of processed and dried green beans, but roasting reduces this to around 2.5%. As well as water that is already present in the green beans, additional water is created by chemical reactions. However, this is vaporized during roasting.

The loss of moisture and the transformation of some dry matter into gases is why beans have a reduced overall mass after roasting. On average, beans lose 12–20% of their weight. Roasters often keep track of percent weight loss to help identify which batches might deserve extra scrutiny in quality assurance.

Different roasting profiles will influence when dehydration takes place. Changes in water activity at different points of the roast can mean a difference in chemical reactions and this may have an impact on final profile.

### *Volume & Porosity*

Coffee beans have some of the strongest cell walls in the plant kingdom. They have external rings that reinforce the cell, increasing its stiffness and strength.

When coffee is roasted, the increased temperature and transformation of water into gas create high levels of pressure inside the beans. These conditions change the structure of the cell walls from rigid to rubbery. This happens because of the presence of polysaccharides (bonded sugar molecules).

The internal matter pushes out towards the cell walls, leaving a gas-filled void in the center. This means that the beans expand in volume as they decline in mass. Much of the gas build-up is carbon dioxide that will be released after the roast.

Roasting also increases porosity, making the beans less dense and much more soluble. This, of course, is vital to making them into a delicious drink.

### *Oils*

Coffee beans contain lipids, or oils. During roasting, the high internal pressure causes these compounds to migrate from the center of the cell towards the surface of the beans.

The lipids help to keep volatile compounds inside the cell. Volatile compounds are chemicals that have a high vapor pressure at room temperature, some of which are essential to creating the flavour and aroma of coffee. Without the oils, they might disperse.

The longer the roast, the more pronounced the structural transformations. Bean density decreases continuously, more gases are developed as time passes, and in a very dark roast, you may see oil migrate to the surface of the beans.

These developments go some way to explaining why a dark-roasted coffee tastes different to a light-roasted one, but there are also significant chemical transformations that impact profile. We’ll take a look at those in part two.

## What Happens When: The Stages of Roasting

Different roast profiles have an impact on the final taste, aroma, and mouthfeel of your coffee. This is because there are different opportunities for chemical reactions to take place.

But whatever roast profile you choose, there are three main phases: drying, browning or the Maillard reaction, and development. These popular terms actually describe different stages of chemical and physical changes.

### *Drying*

The drying phase starts immediately after the turning point. (When you add cold beans to a roaster, the heat inside the machine falls before rising again. The point at which it begins to rise is the turning point.) During drying, water content begins to vaporize and pressure starts to build inside the beans.

### *The Maillard Reaction*

When you see the coffee beans start to turn brown, the Maillard reaction has started. This happens at around 150°C/302°F. During the Maillard reaction, gases including carbon dioxide, water vapor, and some volatile compounds are created. The internal pressure increases enough to break the cell walls of the beans, making a pop. This event is known as first crack.

**Melanoids** begin to develop during this stage. As well as changing the color of the beans, they contribute to the final mouthfeel of the coffee.

### *Development*

After first crack, the roast changes from an endothermic reaction (the beans absorb heat from the drum) to an exothermic one (the beans release heat). During this stage, the physical transformations continue – beans increase in porosity, oils migrate to the walls of the cell, and the color darkens. A lot of chemical reactions also take place during this stage, which we’ll discuss in part two.

Although it may seem straightforward, coffee roasting is a complicated process that includes a number of physical and chemical transformations. All of them are made possible because of the unique structure of the coffee seed.

So next time you empty the roaster or buy a bag of coffee, stop to consider the fascinating processes that each bean has been through to get there.