

# Advanced Level Craft Roasting

Roasters Guild Accredited Class - J16

(Handouts)



Roasters Guild Class:

## **Advanced Level Craft Roasting Class J16**

This advanced level class will focus on the chemistry of roasting. The lecture portion of the class will address the physical changes to the coffee bean during roasting and the primary chemical effects of heat application over time. Instruments and measurements used in analyzing a roast will also be reviewed. The roasting exercise part of this class will feature measured experiments used to demonstrate the ideas presented in the lecture. The class will conclude with cupping, where participants will see how the information and experiments presented come together into the experience of the final product. This is a Roasters' Guild Journeyman Level accredited class. Class J16

Today is the very first advanced roasting class the Roasters Guild has offered. This class contains approximately 65% lecture and 35% hands on roasting and cupping:

Saturday May 3, 2008 9:00 am – 12:00 pm (3 hrs)

### **CLASS AGENDA:**

Opening introductions of Instructors and Station Leads

Lecture:

Visible physical changes to the coffee bean during roasting happening in a simultaneous and concurrent manner

- Color changes (bean absorbs heat and slowly changes from a green color to a yellowish/ then yellow / then light brown / then brown and if the roast continues the bean will become dark brown and the oils may become exposed.)
- Growth of the bean during roasting: water moisture, bound and free, will evaporate fracturing the bean structure cell and releasing enormous amounts of energy. The bean will almost double in size, while at the same time loose non bound moisture. Shrink can be recognized to be between 15% and 25% depending on the roast level.
- Chaff (silver skin) flaking off the bean (before the first crack)
- Release of bound oils onto bean exterior. All coffee has natural oils which will come to the surface at one point or another after the coffee was roasted. The release of the oils can be accelerated if the coffee was roasted dark and even more so if roasted faster. On a light roast the oils are still driven to the surface of the bean but they take longer as the structure of the bean cell was not as fractured during the roast process.
- Scorching (photo)
- Tipping (photo)
- Facing (photo)
- Review **Visuals and Other Green Coffee Changes handout**

Lecture: Non visible physical and sugar development changes during roasting

- Moisture loss (shrinkage, discuss)
- Caramelization: Green coffee has a certain amount of carbohydrates in them. During the roast process these carbohydrates caramelize into sugars and remain in the coffee giving it a certain residual sweetness. Further caramelization can volatilize the sugars completely becoming the residual coffee with a more pronounced bitter taste.
- Sugar Browning and Maillard Reaction (**review ppt and handout explaining Sugar browning, Maillard Reaction and chemical changes through roasting**)

- Chemical changes during roasting (review chemical changes handout)
  - Fats
  - Sugars (Caramelization)
  - Acids: Two primary types of acids in coffee, some are created during the roast (citric, malic), others are natural to coffee and came from the phosphate of the earth where the coffee was planted (phosphoric).
  - Other pertinent compounds: There are many compounds in coffee. Some of these are created during the roasting process while others are dissipated during the roasting process.

Roasting session: Two roasts to the same roast level, but roasting at two radically different profiles: One roast done to offer positive character and one offering negative characters.

- Roast #1 protocol: Allow the green coffee to absorb the heat from the drum and allow the coffee temperature to raise steadily through the entire roast, offering steady development, evaporation of non bound moistures and optimum sugar development.
- Roast #2 protocol: Leave on high heat well past first crack. Pull roast when the coffee reaches the same color as Roast #1. The idea is to create tipping, scorching and facing if possible.
- High Resolution Photo Presentation: Review photos and explain different roast methods for the differing bean cell photos:

Cupping session: Each attendee should have a minimum of 2 cups of each of the two roasts done in their group. Focal points:

- Aroma differences
- Taste differences
  - Body
  - Acidity
  - Flavor

Question and Answer period

# Green Coffee To Roasted Coffee Visual & Others Green Coffee Changes

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Bean Color – Green(nish) > Whitish > Yellow. It darkens to brown when temperature increases.

Bean Surface – Bean surface starts “stretching”. Eventual oils “sweat” to the surface.

Color Difference

Within the bean – Highest color difference for the fastest roasts specially on the light roasts.

Bean Structure – Release of huge amounts of Co<sub>2</sub>. Bean becomes porous.

Brittleness – increases with the degree of roast.

Density – Changes from 600-830 grams/litter to 300 to 460 grams/litter.

Moisture - Liberation of free and chemical bound water.

Organic losses – Mostly chlorogenic acids + carbohydrates + trigonelline + amino acids.

Aroma – Maximum generation at low roast. At medium roast loss is higher than generation.

P.H. – 4.9 low roast to 5.4 dark roast.

(sources: Maier; Clarke; Viani; Illy; Petrarco)

## **Enzymatic Browning**

Unlike coffee roasting which require high temperatures to initiate, enzymatic browning reactions occur spontaneously and at room temperatures. However, like all reactions occurring in nature, a source of energy is required for initial activation. In the case of coffee, the *activation energy* is provided by the heat created by roasters, but in enzymatic reactions - *their* reaction requires the presence of a specific catalyst, or *enzyme*. Simply put, an enzyme is a unique protein that accelerates specific reactions. There are literally thousands of enzymes in biological systems and without them life would come to a grinding halt.

Just like a Russian KGB agent carries a pill of lethal cyanide with him (in the event of capture by enemies), the apple senses that when cut, it's been attacked and immediately jumps into self-defense mode – how? By creating the very same brown polymers we discussed. According to researchers, the brown polymer created during enzymatic browning is highly toxic to bacteria. It's Mother Nature's way of protecting the plant from bacterial infection during its latter, more vulnerable stages of ripening.

Though the benefits of enzymatic browning remain limited to only a handful of products such as raisins, plums, figs, cacao, the reaction is for the most part, a detriment and serious quality concern. Because of its spontaneous nature, enzymatic browning represents a significant economic loss within the fruits and vegetables industry. It's been estimated that at least 50% of all fruits and vegetables goods are damaged due to bruising/tearing during transport to market. As such, scientists have developed relatively simple ways of inactivating enzymes and mitigating browning losses. Blanching, or essentially steaming, is useful as the heat deactivates PPO and prevents browning. Unfortunately not all products can be subject to this and the method is usually limited for products such as shrimp. Another method involves the addition of an acid, usually ascorbic acid, to the pre-oxidized product. Many chefs for example, add a bit of lime juice to fresh guacamole during preparation. Turns out that the decrease in pH prevent the phenols from oxidizing and thus prevent, or at least delay, enzymatic browning.

Fortunately, enzymatic reactions do not play a significant role in flavor development for coffee as compared to products such as tea and cacao (ie.chocolate). Well discuss some of the more complex chemical reactions taking place during roasting in the next set of browning reactions – non-enzymatic browning.

OK - I understand enzymatic browning, but at this point I need to know more about how it related coffee!!! how it effects appearance, taste, aroma, shelf life, etc...

## **Non-Enzymatic Browning**

Unlike the enzymatic browning reactions discussed earlier, these next set of reactions are quite different, but encompass the bulk of the chemical changes occurring during roasting.

*Caramelization*

Caramelization is perhaps the easier of the two non-enzymatic browning reactions to describe. Simply put, *caramelization* is the oxidation or the thermal decomposition of sugars into color and flavors. Although any sugar can be used, sucrose, or commonly known as table sugar, is typically used in several cooking applications. As sucrose is heated to 160C it slowly begins to melt, losing water molecules in the process and becoming a viscous semi-transparent liquid. As heating reaches 200C, the compounds in the molten sugar begin to rearrange, forming brown colored caramel-like compounds and imparting its characteristic burnt/caramel aroma. But this isn't your grandpas caramel! For the caramel created in this process is unlike the caramel candy we've all grown to love as kids. *This* caramel is a bitter/burnt goey compound with little to no sweetness, occasionally used in the toppings such as custard desserts. The caramel *we* know, is created by mixing sugar, milk and other flavorings, but is produced in much the same manner.

Depending on the heating conditions, manufacturers can shift the byproducts of caramelization to either maximize the formation of aromatic compounds, or colored caramel-like compounds. In the latter condition, sugar is heated in the presence of ammonia to produce high concentrations of brown colored compounds, typically used by the cola industry for coloring.

But in addition to creating aroma and color, caramelization creates a broad range of compounds including organic acids in the process. We can clearly see this, for example, in the making of peanut brittle. In the latter stages of commercial brittle making, caramelized sugar is allowed to cool and thicken, at which time baking soda and other flavorings are usually added. The baking soda then reacts with the organic acids produced during caramelization, neutralizing them and to form carbon dioxide gas. The gas then acts as a leaving agent, creating tunnels in the product and producing the characteristic "swiss chesse" texture so commonly found in candy brittle. In coffee, the carbon dioxide created due to the decomposition of sucrose, increases cell pressure within the bean, rupturing it, and ultimately producing the audible "pop" we hear during first crack.

Up to 90% of the initial sucrose is decomposed during roasting to produce a wide range of byproducts, some of which include organic acids such as formic and acetic acid. Studies have shown that acetic acid concentrations in model studies can increase up to twenty times its initial concentration, namely in the early part of roasting, then quickly evaporating in latter stages – due to its volatility. But acetic acid is also unique in that is a relatively weak acid, having effect on coffee quality and acidity. Its no surprise then, that with Arabica containing almost twice the concentration of sucrose as robusta, we usually see a greater intensity of aroma and perceived acidity in the cup.

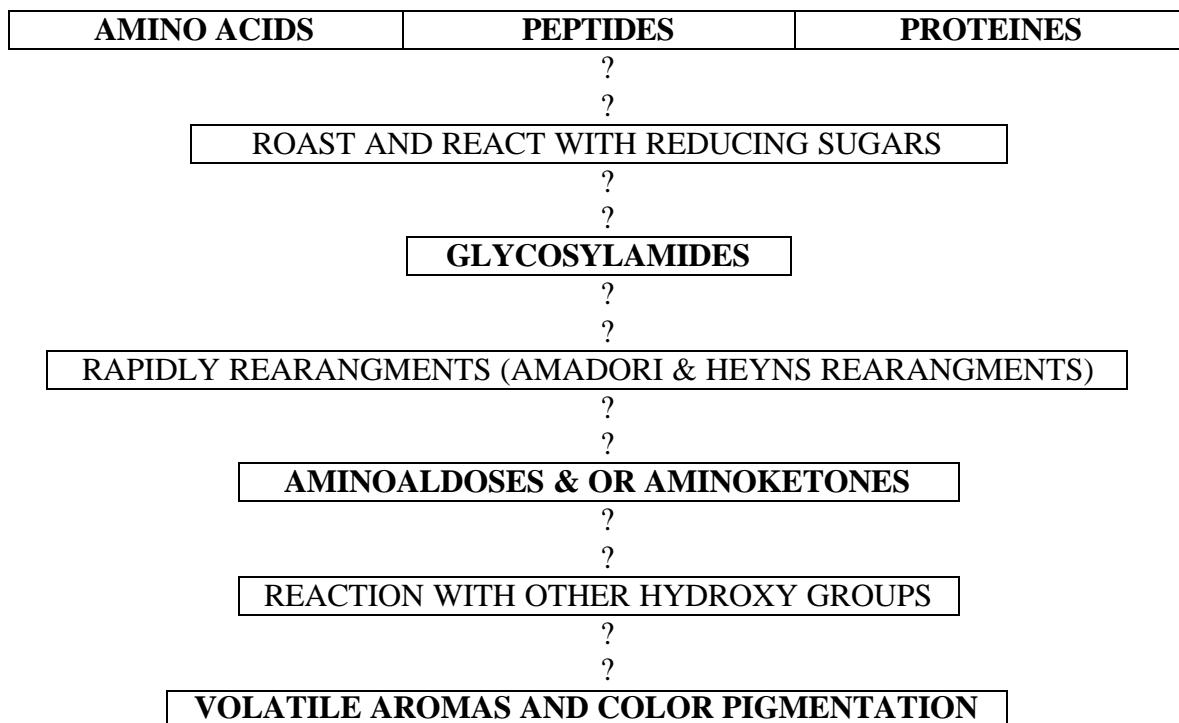
Again, food description are great and much needed to uderstand the science, but we need more coffee information. Does coffee go through a caramelization? or just Maillard?

# Maillard Reaction = Formation of volatile aromas & color pigmentation.

Roasting changes amino acids, peptides and proteins which react with reducing sugars to form glycosylamines / aminoaldoses / aminoketones thru condensation, after reacting with other hydroxyl groups, which form aromas and color pigmentation.

Maillard reaction was discovered 80 years ago but not all its pathways have been identified.

Here's a schematic of the "Maillard development":



## “STRECKER DEGRADATION”

Roasting makes specific amino acids with an  $\alpha$ -dicarbonyl form an aminoketone



Pyrazines and Oxazoles are two main classes present in coffee aroma

# Green Coffee To Roasted Coffee

## Chemical Changes (% Dry Weight)

	<b>Green</b>	<b>Roasted</b>
<b>Caffeine</b>	1.2	1.1
Comments: Very small change thru the roast due to caffeine stability.		
<b>Trigonelline</b>	1.0	1.0
Comments: It shows some decrease thru the roasting forming aromatic compounds.		
<b>Amino Acids</b>	0.5	0.0
Comments: Decomposes with release of Carbon Dioxide and forms volatile aromas.		
<b>Proteins</b>	9.8	7.5
Comments: Are partially transformed in melanoidins.		
<b>Chlorogenic Acid</b>	6.5	2.5
Comments: Changes gradually forming volatile aromas & melanoidins (Co2 release). Loss is proportional to degree of roast & inversely proportional to speed of roast.		
<b>Carbohydrates</b>		
<b>Sucrose</b>	8.0	0.0
Comments: Changes completely forming volatile aromas and caramel.		
<b>Carbohydrates</b>		
<b>Reducing Sugars</b>	0.1	0.3
Comments: see sucrose comments.		
<b>Carbohydrates</b>		
<b>Polysaccharides</b>	49.8	38.0
Comments: Carbohydrates change gradually transforming in polysaccharides (not a lot of decomposition)		
<b>Lipids</b>	16.2	17.0
Comments: Roasting causes migration of the lipids to the bean surface.		
<b>Caramelization &amp; Condensation</b>		
	0.0	25.4
Comments: Transformation thru heat of sugars into flavor & color.		
<b>Volatile Aromatics</b>	Traces	0.1
Comments: Mechanism of volatile aroma formation v. complex and not attributed to a single aroma compound.		
<b>Water</b>	8-14	0-5
Comments: Moisture in bean and chemically bound do evaporate during the roast.		